MEDRAD®

Mark V and Mark V *Plus* Injection Systems Service Manual

Catalog Number: KMP 826

Quality for Life®

KMP 826 Revision K

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Copyright Notice

Trademarks

Mark V Injector, Mark V *Plus* Injector, FluiDot, Medrad, and Quality for Life, are registered trademarks of Medrad Incorporated.

Patents

The *Mark V* and *Mark V Plus* Injection Systems are the subject of the following U.S. patent numbers: 4,677,980; 4,854,324; 5,383,858.

Restricted Sale

Federal (U.S.A.) law restricts the sale of this device to, or by the order of a physician.

Applicability

This manual applies to *Mark V and Mark V Plus* Injection Systems in the following configurations:

Pedestal Mounted Systems:
SYS 500-P, SYS 500, SYS 500 P2I, and SYS P2ID
Control Room Consoles:
RMT 505-P/510-P, RMT 505/510,
RMT 505 P2I/510 P2I, and RMT 505 P2ID/510 P2ID
Remote Panel Systems:
RPS 615(P) and RPS-500

CE 0123

Models SYS500 P2I, SYS500 P2ID, RMT505 P2I, RMT 505 P2ID, RMT 510 P2I, and RMT 510 P2ID are designed to be in compliance with EN 60601-1 (Safety) and EN 60601-1-2 (EMC/Emissions). ECG and Ocilloscope options to the SYS 500 and RMT 505 model systems do not comply with the EN 60601-1-2 standards, and are not available with any P2I system model number.

CE 0123 Represents compliance to the European Council Directive concerning medical devices - 94/42/EEC.

Purpose

This manual is intended to provide instructions for servicing the *Mark V and Mark V Plus* Injection Systems safely and accurately. It is intended for those qualified to service the injection system, whether they be Medrad Service Personnel, Laboratory Service Technicians, or Medrad Authorized Dealers.

Important Safety Notice

The information in this manual is intended for people with adequate backgrounds and experience in electronics and electromechanical devices. Any attempt to repair a sophisticated medical device such as the injector may result in personal injury, property damage, or patient injury.

Disclaimers

Medrad makes no warranties on the contents of this manual, and specifically disclaims any implied warranties of merchantability or fitness for any purpose.

Medrad reserves the right to change specifications and the contents of this manual without obligation.

Medrad reserves the right to modify the specifications and features described herein, or discontinue manufacture of the product described at any time, without prior notice or obligation. Please contact your authorized Medrad representative for the most current information.

External Wiring and Modification: Medrad disclaims liability for any modifications or interfaces with other equipment which are not in conformity with the specifications and information contained within this manual. Such unauthorized action could jeopardize injector operation, safety, or reliability.

Accessory equipment connected to the system interfaces must be certified according the IEC 601-1 standards. Furthermore, all P2I configurations with attached accessory equipment shall comply with the system standard IEC 601-1-1. Anyone who connects additional equipment to the signal input or output configures a medical system, and is therefore responsible that the system complies with the requirements of the system standard IEC 601-1-1. To obtain on-site consulting or consulting references, contact Medrad Factory Service.

All drawings in this manual are for reference purposes only, and may not reflect the construction of units produced prior to the publication of this manual. Reproduction quality of these drawings may have been affected by the level of reduction required. Call Medrad Factory Service if assistance in drawing interpretation is required.

Mark V and Mark V Plus Injectors are not intended for portable use.

Problems or Questions

If you experience problems with any Medrad Injection System, contact:

Medrad Factory Service
MEDRAD, INC.
One Medrad Drive
Indianola, PA 15051-0780
Phone: (412) 767-2400
1-800-MEDRAD-S
1-800-633-7237
FAX: (412) 767-4126

MEDRAD EUROPE, B.V.
Postbus 3084
6202 NB Maastricht
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Phone: (31) (0) 43 3585600
FAX: (31) (0) 43 3650020

Nihon MEDRAD K.K.
Central Shin-Osaka Building 9F
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Osaka, 532-0003
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INTRODUCTION TO WARNINGS / CAUTIONS

This manual contains important information about safe servicing of the *Mark V and Mark V Plus* Injection Systems.

Medrad urges the service technician to read this manual carefully, become familiar with the procedures and system functions that it describes, and follow its recommendations to assure proper servicing of the system.

Warning labels on the *Mark V and Mark V Plus* systems or Warning statements in this manual preceeded by any of the following words and/or symbols are of special significance:

WARNING: Indicates a potentially hazardous situation. If not avoided, this could result in death or serious injury.

WARNING: Indicates electrical hazards which could result in death or serious injury.

CAUTION: Indicates potential hazards or unsafe practices which could cause product, system, or property damage.

NOTE: Indicates helpful information is being offered.

Intended Use

This device is intended to be used specifically for the purpose of injecting intravenous contrast medium into humans, for the purpose of diagnostic studies. DO NOT attempt to use the injector for any other purpose.

Contraindications

This device is not to be used for drug infusion, chemotherapy, or any other use for which the device is not indicated.

WARNINGS

Hazardous voltages exist within the *Mark V and Mark V Plus* Systems that can shock, burn, or cause death. To avoid injury, the system should be opened and serviced by qualified service personnel only. Disconnect the system from line power before cleaning or attempting to perform any maintenance or repairs.

Possible explosion hazard in the presence of flammable anesthetic gases. The *Mark V and Mark V Plus* systems are not designed for use in association with anesthetic gases and equipment.

WARNINGS
(continued)

Disconnect the patient immediately from the injector if any "system malfunction" occurs. If a system malfunction message appears, do not attempt to use the system until the source of the condition has been identified and corrected by qualified service personnel. Do not attempt to recreate any fault conditions while connected to a patient.

Electronic assemblies contain potentially hazardous materials. Dispose of system components or accessories properly. Follow all local regulations for the recycling or disposal of electronic assemblies, or contact Medrad Service for assistance.

Worn power cords or control cables may shock, injure, or cause death. Examine power cords and cables for cuts, frays, or any other visible damage. Do not use the system if any of the cords or cables show signs of damage. Any damaged or worn connection cables or power cords should be replaced.

Check for proper voltage and frequency before connecting the injector to an electrical outlet. Failure to do so may result in personal injury or equipment damage/malfunction. Check the voltage and frequency marked on the back of the unit. Ensure that the outlet providing power to the injector supplies a voltage, frequency, and volt-ampere rating within the range specified.

Do not immerse any injection components in water or any type of cleaning solution. Fluid entry into the system may result in a shock hazard.

Ensure that the FluiDot labels are clearly visible on all pressure jackets. FluiDot labels are intended to help in the avoidance of air embolization, which could result in patient injury or death.

Do not move the injector or pedestal by pulling on the syringe heater cable. This practice will cause the pivot pin to wear prematurely, and may cause the injector head to fall, resulting in possible patient or technician injury.

CAUTIONS

Electrostatic Discharge (ESD). Failure to follow ESD protection practices may result in equipment damage. To avoid damage, ESD protection practices must be followed when servicing any component of this system. If memory components are to be shipped, place the components in conductive carriers (as supplied at Medrad).

Disconnect the power cord before removing or replacing PC boards. Sensitive circuits on the boards can be damaged by abrupt interruption or application of supplies.

Allow system temperature to stabilize before use. When the system is exposed to an extreme temperature change (heat or cold), allow it to stabilize to room temperature before servicing.

Use only accessories and options designed specifically for the *Mark V and Mark V Plus* systems. To ensure compatibility and proper operation, do not use an accessory or option designed for another system.

Perform regular preventive maintenance. To ensure that your injection system remains properly calibrated, and that all primary and backup circuits are functioning properly, regular preventive maintenance is recommended. An annual preventive maintenance package (offered in the U.S.A., Canada, and Europe) is available at an additional cost. Contact your local Medrad Factory Service Representative for details.

Do not soak or immerse any part of the injection system in water. Improper or careless cleaning methods may result in equipment damage. While cleaning any outside portion of the system, avoid allowing any water to seep inside system components.

Do not short the PPI Card Batteries. Do not place the card or the batteries on any conductive surface. When checking or replacing the PPI card batteries, discharge can occur with even a momentary short.

Do not connect injector head extension cables in parallel. Connecting the extension cables in parallel, or extending the total extension length beyond 100 feet (30.5 m), can adversely effect injector performance and specifications.

NOTE: All relevant institutional, local, or national safety regulations related to cable routing and installation should be followed.

CAUTIONS
(continued)

Do not apply voltage to external start lines if the injector is being started by an external start connection. Provide only a switch closure. If the external circuit contains excessive line frequency noise or voltage transients, injector damage or malfunction may result.

Do not plug the cord reel connector into the Auxiliary Start Switch Connector at J13. If not in use, allow the cord reel connector to remain disconnected. This improper connection could result in internal equipment damage or malfunction.

The Remote Start Signal from the film changer programmer (at pins 7 and 9 of J40), must never contain voltage or AC noise. Any voltage applied to these pins can damage the injector and void the warranty. An excess of 50 or 60 cycle AC noise on these lines may cause intermittent problems of premature, or no injections.

The Remote Start Signal from the film changer programmer must remain closed throughout the duration of the injection. If the start signal is removed before the injection volume limits when armed in the SINGLE mode, the injection will stop, the unit will disarm, and display "PREMATURE TERMINATION" on the Control Panel. If the start signal is removed before the injection volume limits when armed in the MULTIple mode, the injection will stop, the Mechanical Stop will reposition at the selected volume, and the unit will remain armed. If a start signal is received at this time, an additional injection will result at the selected Flow Rate and Volume.

When starting the injection process from a remote location by the use of a relay closure in the film changer programmer, always install a "panic button" in series with the start signal. This function must be provided in the event that the operator must immediately terminate the injection. This button should be installed in a convenient location, properly labeled, and instructions for use provided to all users of the injection system.

Do not apply voltage to ISI connector J40 pins 5,6,7,8 or 9. Equipment damage or malfunction may result.

Do not connenct the J19/J20 X-ray connector to the J13 Auxiliary Start connector. Equipment damage or malfunction may result.

3 Condensed Operating Guide

FLOW RATE

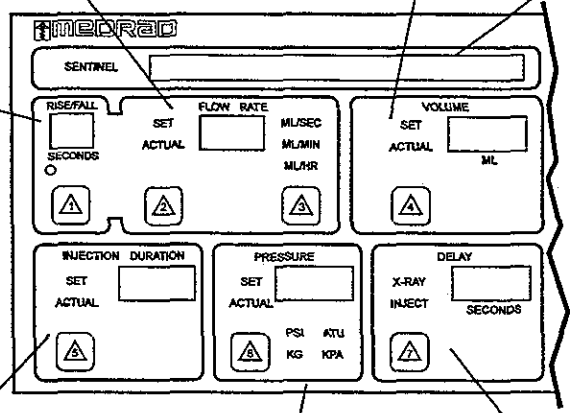
Press Delta 2 to initiate change of FLOW RATE for the injection or the indicated level of a Multi-Level injection currently displayed on the Control Panel. SET light will flash to indicate program change for Flow Rate. Use keypad to select new value. Minimum and maximum Flow Rate values depend on syringe size. Press Delta 2 again to lock in value. SET indicator light will stop flashing and light continuously when the ML value displayed in the Flow Rate Window is locked in. Lighted Flow Scale to the right of the FLOW RATE Display Window is the current Flow Scale.

To select a new Flow Scale, press Delta 3. Press the YES button in response to Sentinel prompt. A new Flow Scale will light. If necessary, repeat the process until the desired Flow Scale is lit.

VOLUME

Press Delta 4 to initiate a program change for the Volume parameter. SET indicator light on panel begins to flash. Use keypad to select new value. Press Delta 4 a second time to lock in new Volume. SET indicator light on panel stops flashing and lights continuously when Volume value displayed in Volume Window is programmed. Range of acceptable values is limited by syringe size and volume remaining in syringe. Volume can be entered in tenths of a ml (one decimal place).

SENTINEL - Displays system messages.



RISE /FALL

Press Delta 1 to change Rise/Fall time. Indicator light above Delta 1 button will flash to indicate program change to Rise/Fall time value. Use the keypad to select a new value from 0 to 9.9 seconds in tenth of a second increments (one decimal digit only). Press Delta 1 Button again to lock in new value. Indicator light stops flashing and lights solid when the value displayed in the RISE/FALL Display Window is locked in.

INJECTION DURATION

Press the Delta 5 button to change Injection Duration. SET indicator light on panel flashes. Use keypad to select new value. Injection Duration time value can be set in tenth of a second increments (one decimal digit). The new value will be displayed in the Injection Duration window. Press the Delta 5 button again to lock in the new value. SET indicator will light continuously when value displayed in the Injection Duration window is locked in. Changing the Injection Duration automatically changes the Volume to be delivered for the injection or level. Normally, Injection Duration is automatically set and calculated when other dependent injection parameters are programmed.

PRESSURE

Press Delta 6 to initiate a change of the Pressure value displayed in the Pressure Window. SET indicator, above Delta 6, begins to flash. Use the keypad to enter a new Pressure value. Press Delta 6 a second time to lock in the change. SET indicator stops flashing and stays lit when the value displayed in the Pressure Window is locked in. Minimum and Maximum Pressure values depend on syringe size and selected Flow Scale.

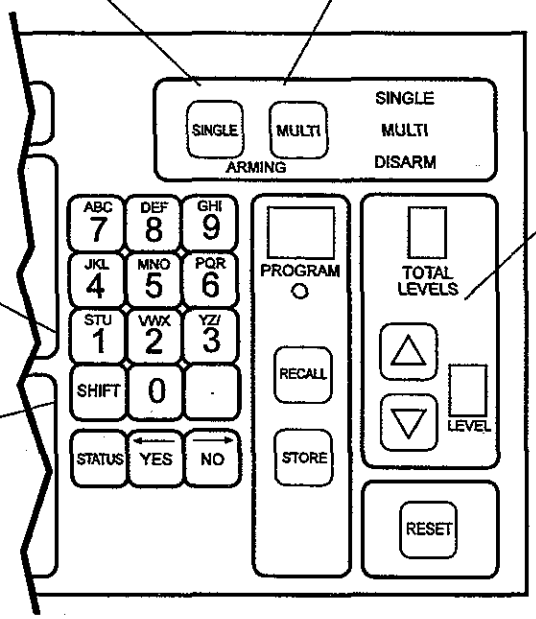
X-RAY OR INJECT DELAY TIME

Press Delta 7 to initiate a change for Delay time and/or type of delay being set. The Delay value, displayed in the Delay Display Window, will reset to 0. Whatever indicator light is flashing, X-RAY or INJECT, that is the type of delay being programmed. To change the type of delay being programmed, press Delta 7 again before entering any Delay value. Use the keypad to select new Delay value. Press Delta 7 to lock in the Delay time. Indicator stops flashing and lights continously when the value displayed in the Delay Window is programmed. Minimum and maximum delay values are from 0 - 99.9 seconds in tenth of second increments (one decimal digit only).

ARMING

SINGLE Arm Button - After entering all injection parameters, press this button to begin the arming sequence for a Single Injection. The DISARM indicator will be lit and will remain lit until arming Sentinel message is answered. After proper responses to Sentinel, the unit will be armed. The DISARM indicator will extinguish and the SINGLE indicator flashes. Injector is armed and ready to inject.

MULTI Arm Button - After entering all injection parameters, press to begin the arming sequence for MULTIple injections. The DISARM indicator remains lit until Sentinel prompts are confirmed. When MULTI indicator on panel begins to flash, the injector is armed for Multiple Injections. During a Multiple Injection the unit does not disarm after the injection. Instead, the injector automatically re-arms after each injection as long as a sufficient volume remains in the syringe.



Alpha-Numeric Keypad - This keypad is the operator's input device. It is used to select new values for injection parameters, select a program number to be stored or recalled, enter a title for a stored injection, or respond to Sentinel prompts.

SHIFT Button - The Shift button is used to select between letters or numbers on the alpha-numeric keypad during the program storage procedure.. Press this key if the title is to contain letters.

LEVELS

TOTAL LEVELS Window - Displays the number of levels contained in the currently displayed injection program. An injection may have up to 4 levels.

LEVEL Window - Displays the level number currently displayed on the control panel. Up to 4 levels may be programmed.

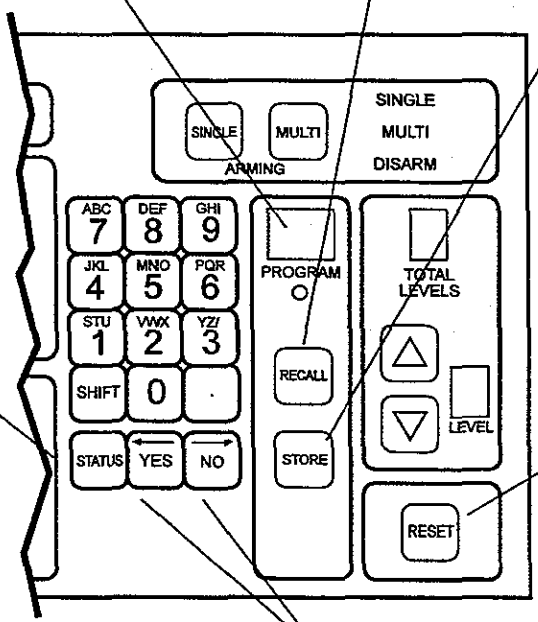
LEVEL UP and DOWN ARROW Buttons - Use these keys to advance up or down one level of a multiple-level injection. The LEVEL window next to the arrow buttons will display the current level.

PROGRAM STORE/RECALL

PROGRAM Window - Displays the program number of a recalled injection program. The number will be displayed as long as no modifications to the program recalled from memory are made.

Press the RECALL Button to recall a previously stored injection program or a system utility program. Injection programs are stored in locations 1 through 49. Storage location numbers 50 - 65 are reserved for system utility programs. The procedure for recalling any stored program is to first press the RECALL button, then enter the number of the program to be recalled. Press RECALL a second time to bring the program into active memory. The number of the program is displayed in the Program window. If any modifications are made to the recalled program, the program number will extinguish to show that the program displayed on the Control Panel is not the same as the one stored in memory.

Press the STORE Button to store injection parameters in permanent memory. Sentinel prompts with next available storage location number. Use the keypad to enter the number, then press the STORE button a second time. Sentinel prompts for a title. Use the keypad to enter a title if desired. Press the STORE button after entering the title. All currently displayed injection parameters are stored in permanent memory.



STATUS

STATUS Button - A toggle switch that allows a user to compare ACTUAL values to SET values. Press after an injection to have ACTUAL injection parameters displayed. The ACTUAL indicator light will light (the SET indicators will extinguish). Values displayed in the various windows are Actual values. Press the Status button again. The SET indicators will light and the values displayed in the various windows are the programmed values. The Sentinel will display CUMULATIVE PATIENT VOL XX.X ML. This number represents the total volume delivered since the control panel was last reset with the RESET button.

RESET

Press RESET to clear Cumulative Patient Volume, set the Control Panel display values to zero, or recover from a fault condition. Sentinel will prompt to confirm resetting of Cumulative Patient Volume and Control Panel values. Press RESET immediately after power up to display software version number of currently installed system software.

SENTINEL RESPONSE AND ARROW BUTTONS

YES/NO ARROW Buttons - These buttons serve a dual purpose. Their primary purpose is to serve as a means to respond to Sentinel prompts. These keys are also used when entering the title of a stored program. Use the NO arrow key after entering each character or space in the title. Use the YES arrow to delete characters and spaces.

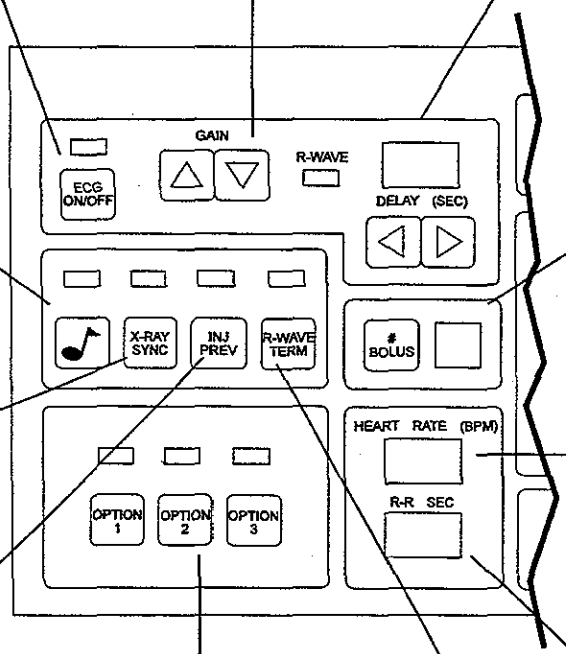
ECG/Scope Control Panel
ECG Trigger

ECG ON/OFF Button - Power switch for ECG panel. Press to turn power on. Press a second time to turn power off. Whenever power is applied to the ECG panel, the light above the ON/OFF button will be lit.

GAIN up/down Arrow Buttons - Press up arrow to raise the gain of the ECG signal coming from the monitor or directly from the patient. Press the down arrow to lower the gain. When gain is properly adjusted, the R-WAVE indicator light to the right of the gain arrow keys will light with each heartbeat.

DELAY (SEC) Window - Displays the length of time after the R-wave until the injection begins (position of intensified dot). Use the arrow keys below the Delay window to adjust the delay time. Delay time is shown in hundredths of a second. Maximum delay time is 0.99 seconds.

MUSICAL NOTE Button - A toggle switch that allows a user to select an audio tone to sound with each R-wave. When this function is activated, the light above the musical note key will be lit.



BOLUS Button and Window - Press the # BOLUS button to program the number of boluses to be delivered during the injection program. Each press of the # BOLUS button increases the number of boluses by one. Up to 9 boluses may be injected during a single injection. The number scrolls back to number 1 after reaching number 9. Number of boluses for a given injection is displayed in the window next to the # BOLUS button. Total injection volume (#Bolus x Volume) is displayed on the Sentinel.

X-RAY SYNC Button - Use this key to synchronize X-ray to the ECG R-Wave. When this function is turned on, a signal is available to sychronize the image acquisition with each R-wave. This ensures that a film will be in place for each bolus injected. The light above this key will illuminate when X-RAY SYNC function is on.

HEART RATE (BPM) Window - Displays the patient heart rate in beats per minute.

INJ PREV Button - Allows the user to preview an injection by displaying waveforms and simulating the injection on the scope. The indicator light above the INJ PREV button will illuminate when this function is on. The injector cannot be armed when INJ PREV is on. No signals to external equipment are sent during an injection preview.

R-R (SEC) Window - Displays the time, in hundredths of a second, between each R-wave.

OPTION Buttons 1, 2, and 3 - Press Option 1 to provide an Injector Delay at the beginning of an ECG triggered injection. Enter the INJECT DELAY is from the Main keyboard. Option 2 and 3 keys are reserved for future expansion. They have no function at this time.

R-WAVE TERM Button - Controls whether or not an injection can continue through the next R-wave, or be automatically terminated by the next R-Wave. Press the R-WAVE TERM button to turn this function on. The light above the button ilights to indicate that this feature is active. The default setting is OFF.

ECG/Scope Control Panel
Scope (Patient Monitor)

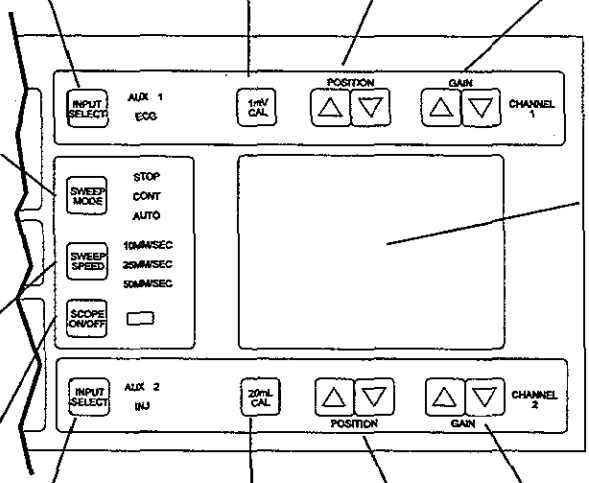
CHANNEL 1 INPUT SELECT Button and Indicators - Press the INPUT SELECT button to choose what will be displayed on CHANNEL 1, (the waveform displayed on the top part of scope). Usually the patient's ECG waveform is displayed on this channel. Press the INPUT SELECT button to toggle between ECG and AUX 1. Check the lighted indicator to see what input signal is being displayed. Use the Position and Gain controls to adjust the Channel 1 signal.

1mV CAL Button - Causes the trace on Channel 1 to move up 1mV. Enables operator to calibrate the Gain to the grid lines on the display. Calibration is accurate only when using an ECG pre-amp and connecting the ECG input directly to the patient. Do not use the 1mV CAL button if there is a a high-level ECG input connected to the injector, or if AUX 1 is selected.

CHANNEL 1 POSITION Up and Down Buttons - Press to change the vertical position of the trace on Channel 1.

CHANNEL 1 GAIN Up and Down buttons - Press to change the size (height) of the Channel 1 deflections. Changes the size of the waveform on the Channel 1 portion of the scope.

SWEEP MODE Button and Indicators - Lighted mode next to button, (STOP, CONT, and AUTO), indicates currently selected mode. Press the SWEEP MODE button to advance to next mode setting. Sweep Mode determines if the scope display will move all the time (CONT mode), start and stop with the injection (AUTO mode), or freeze the image (STOP mode).



OSCILLOSCOPE SCREEN - Displays two waveforms.

SWEEP SPEED Buttons and Indicators - Illuminated speed value on panel, (10 MM/SEC, 25 MM/SEC, 50 MM/SEC Indicators) is the currently selected speed . Press the SWEEP SPEED button to advance to next sweep speed. 25 MM/SEC is the usual standard setting.

SCOPE ON/OFF Button - Press to apply power to the Oscilloscope. Indicator light above button illuminates whenever power is applied to scope and related controls. Press button a second time to remove power from scope section of ECG Control Panel.

CHANNEL 2 GAIN Up and Down buttons - Press to change the size (height) of the Channel 2 deflections. Changes the size of the waveform on the Channel 2 portion of the scope.

CHANNEL 2 INPUT SELECT Controls and Indicators - Press the INPUT SELECT button to choose what will be displayed on CHANNEL 2. Usually a profile of the injection is displayed on this channel. Press the INPUT SELECT button to toggle between INJ and AUX 2. Check the lighted indicator to see what input signal is being displayed. Use the Position and Gain controls to adjust the Channel 2 signal.

20 ML CAL Button - Causes the trace on CHANNEL 2 to move up 20 ML. Enables operator to calibrate Gain to grid lines. INPUT SELECT must be set to INJ and the Sweep Mode must be set to CONTinuous.

CHANNEL 2 POSITION Up and Down Buttons - Press to change the vertical position of the trace on Channel 2.

NOTES:

4 Preventive Maintenance

This section contains recommended procedures for preventive maintenance of Mark V and Mark V *Plus* injection systems. Routine maintenance and inspection will:

- Ensure the continued performance of your injector.
- Reduce the possibility of equipment malfunction.

Recommended Procedures

Preventive maintenance of the injection system should consist of four procedures: Inspection, cleaning, performance checks, and leakage checks. This section contains guidelines, recommended methods, and expected results for each of these procedures:

1. *Inspection:* This first step should encompass inspection of the entire system, looking for obvious signs of damage, such as; cracks in the housing, frayed or worn cables, missing or damaged labels, and contrast spills that may have leaked into the injector.

2. *Cleaning:* This cleaning procedure involves thorough cleaning of the console and head to remove any deposits of contrast medium. If any substances have leaked into any part of the unit, the subassembly should be disassembled and thoroughly cleaned.

3. *Electrical Leakage / Ground Continuity Checks:* To ensure the safety of the patient and hospital personnel in injector operations.

4. *Operational Checkout:* A complete functional performance checkout of the injection system.

Recommended Schedule

Your Mark V or Mark V *Plus* Injection System must be properly maintained to ensure that it is in peak operating condition. Your individual maintenance schedule depends upon how your injector is used; the type of procedures performed, and frequency of use. The following guidelines represent a suggested maintenance schedule:

Daily:
Before use each day, the system should be inspected, and the piston rod thoroughly cleaned.

Monthly:
Once a month, the entire system should be thoroughly inspected and cleaned, and an operational checkout should be performed.

Annually:
Once per year, Electrical Leakage and Ground Continuity checks should be performed.

NOTE: Local regulations or hospital protocol may require electrical leakage checks at more frequent intervals. If this applies, local regulations for leakage must be followed.

Medrad also recommends that a complete system calibration and performance checkout, by a qualified Medrad Service Representative, be performed once a year. Contact Medrad Factory Service, or your local Medrad office for details.

In the United States, Canada, Europe, and other select areas of the world, the Medrad Service Department offers Preventive Maintenance Programs. These annual programs greatly assist in maintaining accuracy and reliability, and can extend the life of the injection system. Contact Medrad for details. In Europe, contact Medrad Europe B.V., or your local dealer, for further information. Refer to Section 2 of this manual for address and telephone numbers.

NOTE: Failures which occur due to lack of proper maintenance, or abuse, will not be covered under warranty.

Inspection Procedures

The following procedures are recommended for the Injector Head, Control Unit, Remote Panel (if the system is so equipped), and mounting systems. If defects are detected, either repair the system, or call Medrad for service. Do not use the unit until the problem has been corrected.

Injector Head

1. Inspect the head case for any cracks that could allow fluid to leak inside, or weaken the case.
2. Inspect the head cable for cuts, cracks, or worn areas.
3. Inspect the head connector for cracks, loose pins, or a loose strain relief.
4. Inspect the Pressure Jackets for small cracks, crazing, or discoloration. As a matter of preventive maintenance, we recommend replacement of the pressure jackets annually.
5. Inspect the syringe heater and cable; look for cuts, cracks, or any worn areas.
6. Inspect the Control Panel for cuts or cracks that could allow fluid to leak inside.

Control Unit

1. Inspect the Control Unit and Control Panel case for cracks that could allow fluid to leak inside, or weaken the assembly.
2. Inspect the power cord for cuts, cracks, or worn spots. Inspect the plug for cracks, loose prongs, loose wires, or a loose strain relief.
3. Inspect the handswitch and cord: Look for cuts, cracks, or worn spots in the cable; look for cracks and loose parts in the switch and housing.
4. Inspect the film changer connector and cord: Look for cuts, cracks, or worn spots in the cable; look for loose pins, or a loose strain relief on the connector.
5. Inspect any other cables connected to the control unit: Look for cuts, cracks, or worn spots in the cables; look for cracks, loose pins, or loose strain reliefs on the connectors.

Remote Panel

1. Inspect the Remote Unit and Control Panel case for cracks that could allow fluid to leak inside, or weaken the assembly.
2. Inspect the interface cable for cuts, cracks, or worn spots. Inspect the connector for cracks, loose prongs, or a loose strain relief.
3. Inspect the handswitch, cord, and connector: Look for cuts, cracks, or worn spots in the cable; look for cracks and loose parts in the switch, housing, and connector.

Pedestal Mount

1. Inspect the case and legs for cracks and other defects that could weaken the structure.
2. Ensure that all mounting bolts and screws are secure.
3. Inspect the connectors on the pedestal for cracks or loose pins.
4. Ensure that the casters roll smoothly, with no binding and scraping.
5. Ensure that the locking mechanism on all locking casters is functional.

Injector Head Support Arm

The injector head support arm is typically associated with pedestal type injection systems and free standing injector head stands. Carefully inspect the areas shown below for any signs of damage.

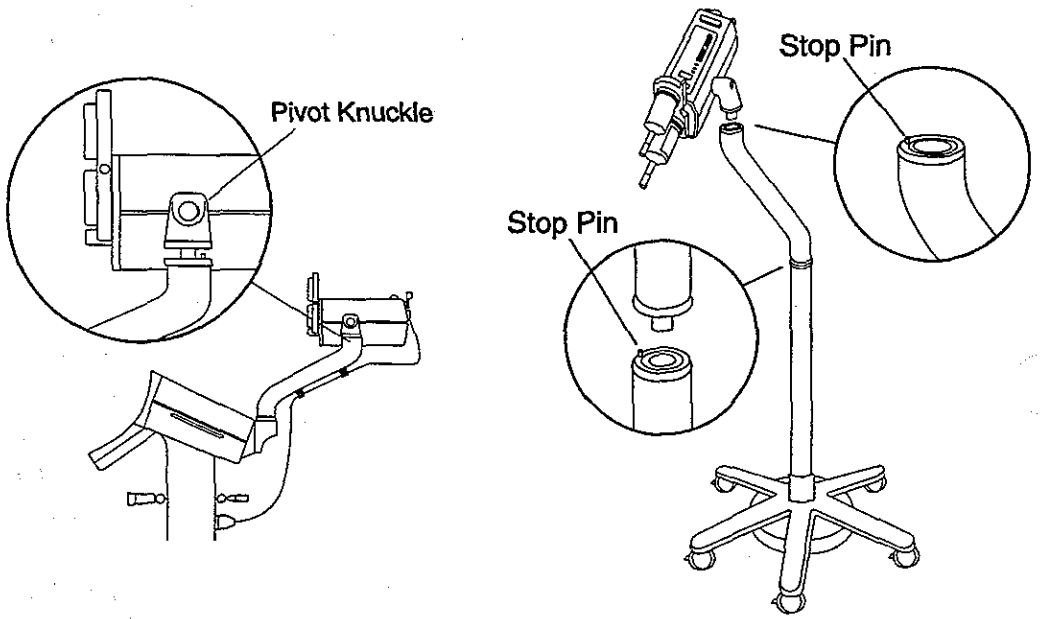


Figure 4.1: Head Supprt Arm Inspection

The injector head pivot knuckle should rest flat and rotate smoothly on the support arm. The injector head, or support arm, should not rotate more than 360 degrees. If either assembly is able to rotate more than 360 degrees, one or more of the stop pins is not properly positioned, or is missing.

If the stop pins are not in the proper position, the head cable can wrap around the support arm, causing damage to the head cable, and possibly lifting the injector head from the support arm. Contact Medrad Factory Service for support arm replacement information.

Counterpoise Systems

1. Inspect all parts of the mounting system for cracks and other defects that would weaken the assembly.
2. Ensure that the mounting system is securely assembled, with no loose parts. The system should be stable with the head installed.
3. Ensure that the system moves smoothly in all directions, with no binding, scraping, or drifting.
4. Verify that all cabling is tied back and does not interfere with the movement of the supporting parts or the injector head.

NOTE: All relevant guidelines for institutional, local, or national safety recommendations related to cable routing and installation should be followed.

Syringe Heater

1. Ensure that the device is warm to the touch.
2. Ensure that the LED indicator is not illuminated or flashing when installed on the pressure jacket/syringe. The lamp may illuminate if the syringe heater is not installed on the pressure jacket/syringe.

   If the lamp is illuminated while the heater is installed on the pressure jacket/syringe, the heater is too hot and should be replaced.
3. Inspect the cable and connector for cracks, worn areas, loose pins, or a loose strain relief.

Cleaning Procedure

Deposits of contrast media can interfere with proper operation of the Mark V and Mark V *Plus* Injection Systems. The following guidelines should be followed when removing deposits, or cleaning any portion of the system.

WARNING: Remove the power cord from the power source before cleaning any part of the system. Failure to do this could result in the exposure of lethal voltages, causing injury or death.

- Using warm water and soft cloths, clean the injector console and head thoroughly to remove contrast medium or other deposits.

- The injector head requires particular attention. Remove the turret, then: Clean the front casting where the piston moves in and out; Clean the turret and its pivot point; Remove any contrast from the entire length of the piston rod.

CAUTION: Do not soak or immerse any parts of the injector in water. Improper or careless cleaning methods may result in equipment damage. While cleaning the outside of the unit, avoid letting any liquids seep inside injector components.

- If contrast medium has leaked inside the head or console, the affected subassembly should be disassembled and cleaned. This cleaning procedure can be done in the field by trained Medrad Service personnel, or returned to Medrad Factory Service. If the cleaning will be performed in the field by a properly trained individual, ensure that any internal wiring or components are not disturbed, and that the system is completely dry before applying power.

- Check all of the System Safety and Warning Labels for legibility. Ensure that the labels are not damaged or missing.

WARNING: Ensure that the system is completely dry before connecting to a power source and applying power.

Leakage Check

To insure safe operation of the injector, a leakage check must be part of regular preventive maintenance.

Use a commercial leakage tester such as one of the following:

Manufacturer	*Model*
Bio-Tek Instruments, Inc. Electrical Safety Analyzer	Model 501
Dynatech Nevada, Inc. Electrical Safety Analyzer	PEI Model 2000A
Ohmic Instruments Co.	BET-300 Series *or* HSM-200 Series
Bender	Safety Tester 601 *or* Unimet 1000 ST

1. With the AC ground open, power applied, and the line at normal, leakage should be less than 100 micro amps.
2. With the AC ground open, power applied and the line reversed, leakage should be less than 100 micro amps.
3. Disconnect the leakage test box.

Ground Continuity Check

A ground continuity check must also be a part of regular maintenance of the Mark V and Mark V *Plus* Injection Systems.

1. Disconnect the injector from the power source.
2. Using an ohm meter, measure the resistance between the ground terminal on the power cord and any exposed metal suface of the system. The resistance measured must be less than 0.2 ohms.

NOTES:

5 Checkout Procedure

Introduction

These checkout procedures test the major functions of the Mark V and Mark V *Plus*. These procedures should be followed:

- Before using the unit for the first time
- As part of a routine preventive maintenance program (check operation monthly with this procedure)
- If a problem or miscalibration is suspected
- After repairs

Read the steps first, then do them. Many steps require more than one observation. Some steps will need to be timed.

To do these checkouts, a stopwatch, a watch with a digital seconds timer or seconds hand, or a timer is required.

NOTE: If the unit fails to perform as outlined in any of the following procedures, or any error messages appear, refer to Section 19, Troubleshooting Guide.

Basic Unit Checkout Procedure

This procedure checks the basic functions of any Mark V or Mark V *Plus* system. Regardless of the configuration or what options are on your system, start with this procedure. Then continue with the others in the order they appear in this section.

This procedure is valid for all models and configurations of the Mark V or Mark V *Plus* injector including the RMT 510 model in which the system is operated solely from a Remote Panel, with no Control Panel on the console. With this kind of system, any reference to a Control Panel in the following procedure refers to the Remote Panel.

Injector Head Mount Inspections

A safe and effective injector mounting system must be maintained to prevent personal injury and/or equipment damage. An important part of inspection should include the injector head support arm typically associated with pedestal injector systems (SYS 500 or SYS 500-P) and the free standing injector head stand (KMA-320 or KMA-320T). The injector head pivot knuckle should sit flat and rotate smoothly on the support arm. The injector head should not rotate more than 360 degrees. Periodically lift the head from the support arm and check for the presence of the injector head stop pin. If the pin is not in place, the head cable can wrap around the arm, causing damage to the head cable and possibly forcing the injector head off of the support arm. The support arm should be inspected for cracks where the head rests on the arm and at the base where it is attached to the injector or the injector head stand. If a crack is present, the crack can lengthen, compromising the integrity of the arm.

Initial Checks

1. Get the injector ready:

   With the exception of the head cable, disconnect any cables from the connector panel on the back of the injector.

   If your system is a Control Room Console without an integral Control Panel, leave the Remote Panel connected. If your system includes a Remote Panel and has a Control Panel on the console, disconnect the Remote Panel.

   Remove and discard any syringes from the pressure jackets on the injector head.

   Rotate the turret to the vertical (or ready to inject) position.

   Position the Rotating Piston Plunger Release lever on the back of the injector head horizontally.

2. Check the initial response of the injector.

   Connect the system to a compatible electrical power source, then apply power. The SENTINEL should display:

   SELF TEST IN PROGRESS VER MV (or PR) X.X

   The MV (or PR) X.X message indicates the software version installed in the unit. During the self test, all LEDs on the Control Panel should illuminate, and all windows should display 8's and decimal points. If any segments do not illuminate, the unit requires repair and should not be used.

Injector Head

2. Fully advance and retract the injector head plunger using the load controls on the head control panel. Ensure that the plunger moves freely, without binding, rubbing, or scraping.

ML/SEC

3. Enter the following injection parameters

RISE / FALL	0 Seconds
FLOW RATE	10 ML/SEC
VOLUME	25 ML
INJECTION DURATION	2.5 seconds
PRESSURE	1000 psi
X-RAY DELAY	2 seconds

Arm the injector in the SINGLE mode, then inject. When the injection is complete, check the injection STATUS, verifying that the actual results fall within the following ranges:

FLOW RATE	9.2-10.8 ML/SEC
VOLUME	24.1-25.9 ML
INJECTION DURATION	2.2-2.8 seconds
PRESSURE	less than 100 psi
X-RAY DELAY	2 seconds

ML/MIN

4. Enter the following injection parameters

FLOW RATE	59 ML/MIN
VOLUME	29.5 ML
PRESSURE	150 psi

Arm the injector in the SINGLE mode, then inject. When the injection is complete, check the injection STATUS, verifying that the actual results fall within the following ranges:

FLOW RATE	56 - 62 ML/MIN
VOLUME	28.6 - 30.4 ML
INJECTION DURATION	0.4 - 0.6 minutes
PRESSURE	less than 50 psi

ML/HR

5. Enter the following injection parameters:

FLOW RATE	50 ML/HR
VOLUME	25 ML

NOTE: This injection will last approximately 30 minutes. A KMP 551 adaptor can be used to keep the handswitch depressed throughout the injection.

Arm the injector in the SINGLE mode, then inject. When the injection is complete, check the injection STATUS, verifying that the actual results fall within the following ranges:

FLOW RATE	45 - 55 ML/HR
VOLUME	24.1-25.9 ML
INJECTION DURATION	0.4 - 0.6 Hours
PRESSURE	less than 50 psi

Rise/Fall

6. Enter the following injection parameters

RISE / FALL	8 Seconds
FLOW RATE	15 ML/SEC
VOLUME	105 ML
PRESSURE	1000 psi

Arm the injector in the SINGLE mode, then inject. The plunger should accelerate steadily for 8 seconds, then continue at a steady rate for 3 additional seconds. When the injection is complete, check the injection STATUS, verifying that the actual results fall within the following ranges:

FLOW RATE	14 - 16 ML/SEC
VOLUME	103.4 - 106.6 ML
INJECTION DURATION	10 - 12 seconds
PRESSURE	less than 50 psi

Delay Timer

7. Enter the following injection parameters

RISE / FALL	0 Seconds
FLOW RATE	1 ML/SEC
VOLUME	30 ML
PRESSURE	1000 psi
X-RAY DELAY	10 seconds

Arm the injector in the MULTI injection mode, then inject. Carefully listen for an audible click (closing of the internal X-ray trigger relay) approximately 9 to 11 seconds into the injection.

Change the programmed X-ray delay to an Inject Delay of 5 seconds. Arm the injector in the SINGLE mode, then inject. Ensure that the injection begins approximately 5 seconds after the handswitch is depressed.

Pre-Programmed Injections

8. Reset all injection parameters using the RESET function. The Level and Total Levels windows will display a 1, all other windows should display a 0.

   Enter the following injection parameters:

RISE / FALL	4 Seconds
FLOW RATE	28 ML/SEC
VOLUME	112 ML
INJECTION DURATION	6 Seconds
PRESSURE	925 psi
X-RAY DELAY	2 seconds

   Name and store the injection parameters using the STORE function. Remove power from the system for at least one minute, then re-apply system power. Using the RECALL function, recall the stored injection parameters, verifying that the Control Panel windows display injection parameters entered above.

Remote Panel

9. If the injection system is equipped with a Remote Panel in addition to the Control Panel, ensure that the Remote Panel is the Master mode, repeat the ML/SEC, ML/MIN, ML/HR, Rise/Fall, Delay Timer, and Pre-Programmed Injection checks outlined above.

   NOTE: Use the Remote Panel handswitch for all of these injections

End of basic checkout procedure.

ECG Trigger Checkout Procedure

This procedure checks the performance of the ECG trigger section, an option for the Mark V and Mark V *Plus* systems. The function of the ECG trigger is the same for the Mark V and Mark V *Plus* systems. With all systems, follow the basic procedure first, then check the ECG section according to this procedure.

NOTE: The system must be equipped with software version PR3.0 or above to operate the ECG section.

To perform this checkout, connect an ECG input from a simulator to the injector. There are two ways to do this. First, connect the simulator to a monitor, then connect a high-level signal from the monitor to J44 on the back of the injector. The following items are required to complete this section of the checkout:

- High-Level ECG Input Cable (included with ECG trigger option)
- High-Level ECG Signal (such as from an ECG monitor)
- ECG Simulator (see below for suitable choice)

The second way to connect an ECG input is to connect the simulator to the ECG preamp that connects at J44 on the back of the injector. The following items are required to complete this section of the checkout (since the preamp is optional, your system may not include it):

- ECG Preamp PMI 100
- Patient Cable (included with preamp)
- ECG Simulator (see below for suitable choice)

The following ECG simulators, or their equivalents, are suitable for this checkout. All are inexpensive, portable, battery powered, and have adjustable rates:

Manufacturer	*Model*
Biohio Systems Co.	EH-5N
Bio-Tek Instruments, Inc.	ECG/R
Cambridge Medical Instruments	4350
Medi Cal Instruments Inc.	410
Phipps L Bird Inc.	7092-450
Valmedix	323-100

1. With the exception of the head cable, Control Room Monitor, and Analog and Digital cables (Control Room Console only), disconnect any cables plugged into the connector panel on the back (including the Remote Panel if the system includes one).

2. Connect the injector to a power source, then apply power. Ensure that power is applied to the ECG trigger section of the injector, and removed from the Oscilloscope section.

3. Connect an ECG simulator to the ECG input then enter the following injection parameters:

RISE/FALL	0 seconds
FLOW RATE	15 ML/SEC
VOLUME	10 ML
PRESSURE	1000 psi
DELAY	0 seconds, X-RAY

4. Set the ECG simulator to 60 BPM. The HEART RATE window should display a value between 57-63 BPM, and the R-R SEC window should display a value between 0.95-1.05 seconds. Adjust the Gain control as required.

   Enter the following parameters on the ECG Control Panel:

DELAY	0 seconds
# BOLUS	4
R-WAVE TERMination	OFF

5. Arm the injector in the SINGLE mode, then inject. When the injection is complete, check the injection STATUS, verifying that the actual results fall within the following ranges:

FLOW RATE	13.5 - 16.5 ML/SEC
VOLUME	35 - 45 ML
INJECTION DURATION	0.5 - 0.7 seconds
PRESSURE	less than 100 psi

6. Enter the following parameters on the Control and ECG Panels:

RISE/FALL	0 seconds
FLOW RATE	10 ML/SEC
VOLUME	15 ML
PRESSURE	1000 psi
DELAY	0 seconds, X-RAY
DELAY	0.5 seconds
# BOLUS	5
R-WAVE TERMination	ON

7. Arm in the SINGLE injection mode, then inject. The plunger should not move until after the first R-Wave. The plunger should then advance 5 ml, stop, then resume with each subsequent R-Wave.

When the injection cycle is complete, check the injection STATUS, verifying that the actual results fall within the following ranges:

FLOW RATE	9.2 -10.8 ML/SEC
VOLUME	24.1 - 25.9 ML
INJECTION DURATION	0.4 - 0.6 seconds
PRESSURE	less than 100 psi

8. Ensure that the following parameters are entered on the ECG Control Panel:

DELAY	0 seconds
# BOLUS	1
R-WAVE TERMination	OFF
X-RAY SYNC	ON

End of ECG Checkout Procedure

Oscilloscope Checkout Procedure

This procedure provides a basic performance check of the Oscilloscope option (abbreviated Scope) for the Mark V and Mark V *Plus* systems.

1. Apply power to the Scope. Ensure that there are two traces on the screen, then ensure that the following default parameters are displayed on the Control Panel:

SWEEP MODE	CONTinuous
SWEEP SPEED	25 MM/SEC
INPUT SELECT (Top Channel)	ECG
INPUT SELECT (Bottom Channel)	INJ

2. Enter the following parameters:

SWEEP MODE	CONTinuous
SWEEP SPEED	10 MM/SEC
INPUT SELECT (Top Channel)	AUX 1
INPUT SELECT (Bottom Channel)	AUX 2

3. Position the Channel 1 trace at the uppermost Horizontal grid line, then re-position the trace at the lowest Horizontal grid line. Press and hold the CHANNEL 1 GAIN increase arrow for 10 seconds. Press the 1MV CAL button, ensuring that the trace deflects upward 5 to 7 divisions.

4. Position the Channel 1 trace at the third division from the top of the screen. Set the CHANNEL 1 INPUT SELECT to INJ.

5. Position the Channel 2 trace at the uppermost Horizontal grid line, then position the trace at the lowest Horizontal grid line, then re-position the trace at the second line up from the bottom.

6. Set the CHANNEL 2 GAIN to allow the trace to deflect 4 divisions by pressing the 20 ML CAL button.

7. Press and release the 20 ML CAL button. The pulse should take 9.5 to 10.5 seconds to travel across the display.

8. Select a SWEEP SPEED of 25 mm/sec. Press and release the 20 ML CAL button. The pulse should take 3.6 to 4.4 seconds to travel across the display.

9. Select a SWEEP SPEED of 50 mm/sec. Press and release the 20 ML CAL button. The pulse should take 1.8 to 2.2 seconds to travel across the display.

10. Enter the following injection parameters:

RISE/FALL	0 seconds
FLOW RATE	10 ML/SEC
VOLUME	15 ML
PRESSURE	1000 psi
DELAY	0 seconds, X-RAY

11. Arm the injector in the SINGLE mode, then inject. The lower trace should gradually deflect three divisions, then return to the base line.

12. Apply power to the ECG option. Connect an ECG simulator input to J44 on the rear connector panel. Set the simulator for 60 BPM. Ensure that the GAIN is set to allow the R-Wave to flash with each beat of the simulator.

13. Ensure that channel 1 of the scope displays the R-wave, and that the R-wave signal deflects at least two divisions.

14. Enter the following injection/ECG parameters:

RISE/FALL	0 seconds
FLOW RATE	17 ML/SEC
VOLUME	15 ML
PRESSURE	1000 psi
DELAY	0 seconds, X-RAY
DELAY	0.41 seconds
# BOLUS	2
R-WAVE TERMination	ON

15. Set the SWEEP MODE to AUTO, then Arm in the SINGLE injection mode and inject.

16. Ensure that the following events and conditions occur:

- The scope screen will clear when the start switch is pressed, then start sweeping.
- The plunger should start moving on the first R-Wave (after pressing the start switch).
- The bottom trace displays two ramped wave forms, each deflected upward two divisions.
- The start of each ramp coincides with the location of the intensified dot on the ECG waveform.
- The end of each ramp coincides with the R-Wave.
- The scope should stop sweeping approximately 0.25 seconds after the completion of the injection.

17. Select the INJ PREV function on the ECG option. The scope should simulate the previous injection, without actually injecting.

NOTE: Return the syringe size and pressure setting back to those programmed before beginning the checkout procedures.

Notes:

6 CPU Card

There are two versions of the CPU Card, identified by the card revision level, part number, and serial number. Use the table below to determine which card type the user has, then refer to the appropriate description on the following pages.

Assembly No.	Revision	Serial Number	Card Type
78101-10-AP-01	Rev. E and above	Above 20000	Type B
78101-10-AP-14	Rev. A and above	Above 27467	Type C

CPU Card Type B

(Part Number 78101-10-AP-01 (-3), serial numbers 20000 - 27467)
The CPU Card contains the main injector operating program. Refer to the figure on page 6 - 3 for a block diagram of the CPU Card type B. The CPU Card contains the following circuits:

CPU

The Z-80 CPU U10 is supported by 40 Kbytes of EPROM, and 8 Kbytes of RAM. This processor provides a 16-bit address bus, an 8-bit data bus, and several control lines for Read/Write, Interrupts, etc..

Clock

Crystal Y2 (8 MHz) and clock generator chip U2, produce the 4 MHz clock system for the CPU, and provide a Reset pulse when power is first applied. This pulse resets the CPU, and ensures that the program starts at the beginning.

Memory

CPU memory is comprised of four EPROM /PROM chips (U11 through U15), and one RAM chip (U16). These chips connect the address and data buses, and are controlled by the enable lines from the memory / I/O decoder, and the Read/Write lines from the CPU. If these chips need to be replaced, contact Medrad Service for current revision EPROMS.

Memory / Input/Output Decoder

The Memory / Input/Output Decoder, comprised of U22 and U23, provides:

- Control of the memory chips during read/write cycles
- Two major decode lines (MEMIO1 and MEMIO2: Pins 16 and 17) that are buffered and sent to the Input/Output Card
- Direction control for the data buffer

Bus Buffers

The control lines from the CPU are buffered by U17, then sent to the motherboard bus. The address bus is buffered by U18 and U19, then sent to the motherboard bus. The flow of data is controlled by bidirectional buffer U20, which is controlled by the Memory / I/O Decoder. Control and addressing lines flow away from the CPU, while the buffered data bus, can flow in either direction.

Watchdog 1

The CPU watchdog (U3) must receive pulses from the I/O Card on the WATCHDOG 1 line, or CPU operations will be interrupted. The pulses are generated on the I/O Card, by decoding a CPU address. A loss of these pulses is most likely the result of a problem with the CPU or the EPROMs.

Test Section

The circuit surrounding U7 is used for in-house testing, and the enabling of Utility programs.

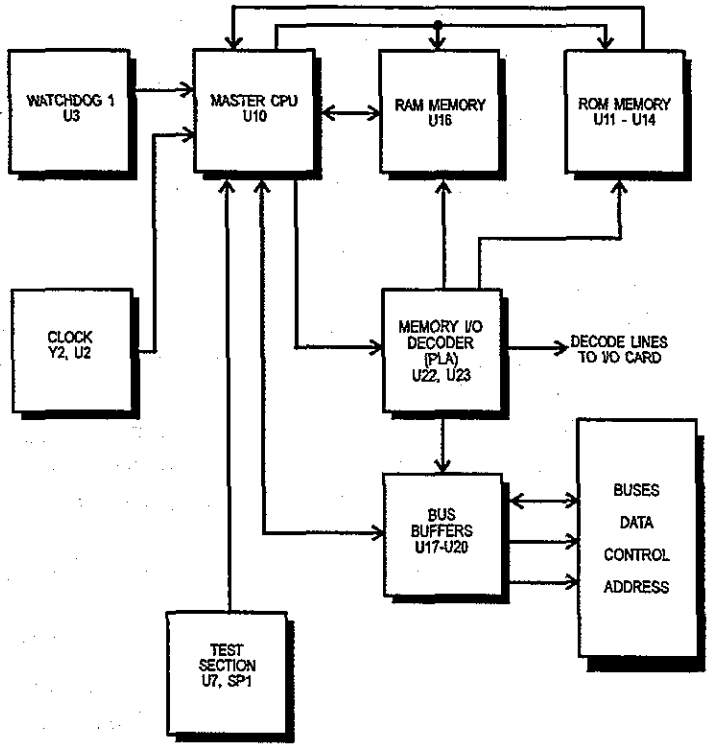


Figure 6.1: Block Diagram: CPU Card Type B

CPU Card Type C

(Part Number 78101-10-AP-14 (-3), serial numbers above 27467)
The CPU Card contains the main injector operating program. Refer to the figure on page 6 - 5 for a block diagram of the CPU Card type C. The CPU Card contains the following circuits:

CPU

The Z-80 CPU U10 is supported by 64 Kbytes of EPROM, and 8 Kbytes of RAM. This processor provides a 16-bit address bus, an 8-bit data bus, and several control lines for Read/Write, Interrupts, etc..

Clock

Crystal Y2 (8 MHz) and clock generator chip U2, produce the 4 MHz clock system for the CPU, and provide a Reset pulse when power is first applied. This pulse resets the CPU, and ensures that the program starts at the beginning.

Memory

CPU memory is comprised of one EPROM / PROM chip (U24), and one RAM chip (U16). These chips connect the address and data buses, and are controlled by both the enable lines from the memory / I/O decoder, and the Read/Write lines from the CPU. EPROM chip U24 is only accessed when switch SP2-2 is set to the "U24" position. If this chip must be replaced, contact Medrad Service for a current version EPROM. In addition to standard memory, a separate EPROM chip (U25) may be installed to access special utility functions. This may be accessed be setting switch SP2-2 to the "U25" position. Contact Medrad Factory Service for more information.

Memory / Input/Output Decoder

The Memory / Input/Output Decoder, comprised of U23 and U26, provides:

- Control of the memory chips during read/write cycles
- Two major decode lines (MEMIO1 and MEMIO2: Pins 16 and 17) that are buffered and sent to the Input/Output Card
- Direction control for the data buffer

Bus Buffers

The control lines from the CPU are buffered by U17, then sent to the motherboard bus. The address bus is buffered by U18 and U19, then sent to the motherboard bus. The flow of data is controlled by bidirectional buffer U20, which is controlled by the Memory / I/O Decoder. Control and addressing lines flow away from the CPU, while the buffered data bus, can flow in either direction.

Watchdog 1

The CPU watchdog (U3) must receive pulses from the I/O Card on the WATCHDOG 1 line, or CPU operations will be interrupted. The pulses are generated on the I/O Card, by decoding a CPU address. A loss of these pulses is most likely the result of a problem with the CPU or the EPROMs.

Test Section

The circuit surrounding U7 is used for in-house testing, and the enabling of Utility programs.

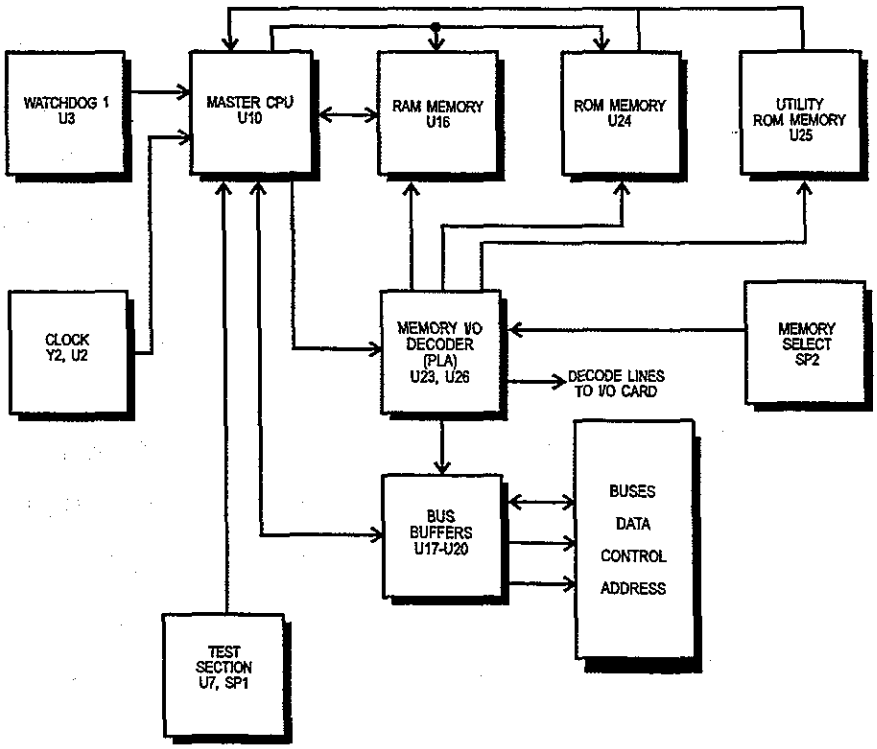
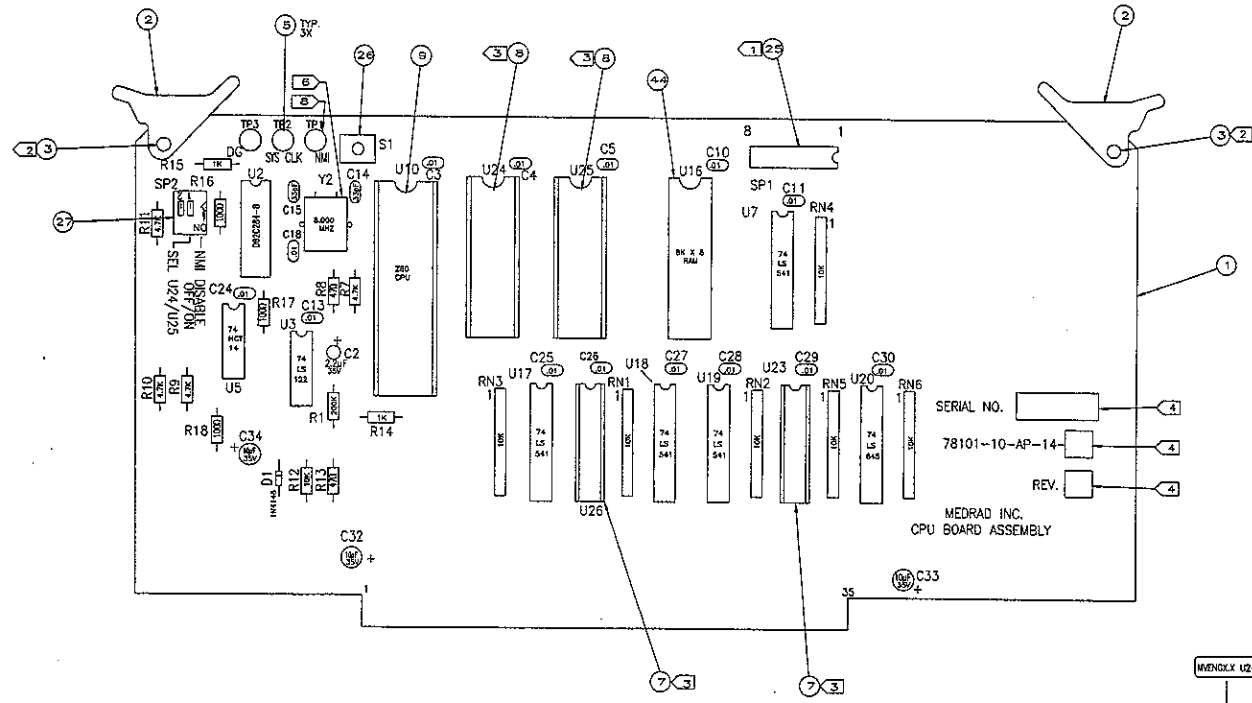


Figure 6.2: Block Diagram: CPU Card Type C

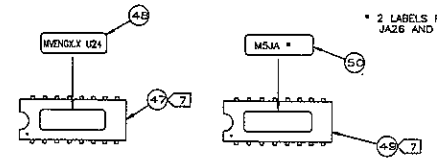
Serial Number	*Card Part Number*	*Chip Designation*	*Chip Part Number*
CPU 2XXXX to 27467	78101-10-AP-01 (-2, -3)	U11	MV 7.0 U11
		U12	MV 7.0 U12
		U13	MV 7.0 U13
		U14	MV 7.0 U14
		U15	MV ENG 7.0 U15 (English)
		U15	MV GER 7.0 U15 (German)
		U15	MV FR 7.0 U15 (French)
		U22	M5JA22
		U23	M5JA23
CPU 27468 and Above	78101-10-AP-14 (-3)	U24	MV ENG 7.0 U24 (English)
		U24	MV GER 7.0 U24 (German)
		U24	MV FR 7.0 U24 (French)
		U23	M5JA23
		U26	M5JA26

NOTE: Additional language configurations may be available. Contact MEDRAD for additional information.

REVISIONS			
REV	ECO NO/EC NO	DESCRIPTION	CHK BY/DATE / APP'VD.
H	EC-2371	CAD REGENERATED, SEE REV. G FOR PRIOR REVS. REVISED ITEM 44	DCS 10-7-96 / TDK 10-16-96
J	EC-2719	REVISED NOTE 7	DMB 5-16-97

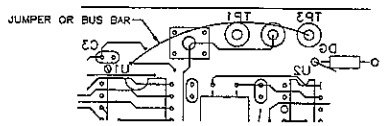


PROCESS COMPATABILITY CHART		
ITEM/ DESIG.	DO NOT WAVE SOLDER	DO NOT WATER WASH
2,3	X	



NOTES:

1. LEAVE PLASTIC CAPS ON SP1 & SP2 DURING WAVE SOLDER AND CLEANING REMOVE DURING TOUCH UP.
2. MASK COMPONENT LOCATIONS FOR PARTS MARKED "DO NOT WAVE SOLDER" PRIOR TO WAVE SOLDER. INSTALL PARTS MARKED "DO NOT WAVE SOLDER" AFTER WAVE SOLDER. HAND CLEAN ANY PARTS MARKED "DO NOT WATER WASH"
3. U24–U25, U26, AND U23 ARE INSTALLED AT A HIGHER LEVEL. COMPONENT DESIGNATORS ARE SHOWN FOR REFERENCE ONLY.
4. SERIAL NO., BOARD P/N (–3) AND REVISION TO BE APPLIED USING PERMANENT INK, OR PRE-PRINTED LABEL (ITEM 6)
5. FOR REV B PC BOARDS ONLY, ADD A 22 AWG JUMPER WIRE (P/N 703-0122-009) OR 22 AWG BUS BAR AND TUBING, (P/N 706-0122-000 & 712-2000-022) ON THE SOLDER SIDE OF THE PCB FROM THE DG TEST POINT (TP3) TO THE FEED THROUGH HOLE ABOVE U10 TO THE LEFT OF C3.
6. USE ADHESIVE TO FASTEN Y2 TO THE BOARD. USE RTV OR EQUIVALENT REMOVABLE SILICON BASED ADHESIVE.
7. PROGRAM PARTS PER INSTRUCTION NO. 94064-00-PX-01.
8. ORIGIN LOCATION, TP1 (NMI).



GEOMETRIC TOLERANCES		STANDARD DIMENSIONING	UNLESS OTHERWISE SPECIFIED	SIGNATURES		DATE
SYMBOL	CHARACTERISTIC	Ø DIAMETER	DIMENSIONS ARE IN INCHES	DRAWN	PAVLOCK	2-3-92
		CBORE/C'DRILL	TOLERANCES ON:	APPROVED	BOLLINGER	2-7-92
		SPHERICAL SPHERE	2 PL DECIMALS ±.01	QUAL.	HINTERMEYER	2-10-92
		SLOPE	3 PL DECIMALS ±.005	RELEASED	YARZEBINSKI	9-5-95
		COUNTERBORE	FRACTIONS 6"=6" ±1/32			
		COUNTERSINK	FRACTIONS 6"=12" ±1/16			
		DEPTH/DEEP	ANGULAR ±0° 30'			
		DIM NOT TO SCALE	DIM SURFACE ROUGHNESS	DO NOT SCALE DRAWING		

MEDRAD® INC.
ONE MEDRAD DRIVE
INDIANOLA, PA 15051-0780

TITLE: FINAL ASSEMBLY, CPU BOARD MKV INJECTOR

SIZE D | DWG. NUMBER 78101-10-AP-14-3 | REV. J

SCALE: 2X | DATE COPIED: | SHEET 1 OF 2

BILL OF MATERIAL

ITEM	DESCRIPTION	PART NUMBER	QTY.	REF. DESIG.	PROCESS CODE	PREP. CODE
1	PC CARD REV E AND UP	78101-10-PC-14	1		LG	
2	CARD EJECTOR, WHITE	510-7000-000	2		AW	
3	CARD EJECTOR PIN	510-7001-000	2		AW	
4						
5	TUBULAR TERMINAL	642-1238-000	3	DG,SYS CLK,NMI	BW	
6	LABEL, BLANK SERIAL NO	550-0093-652	1		BW	NOTE 5
7	IC SOCKET, 20 PIN	545-8201-020	2	U26,U23	LG	
8	IC SOCKET, 28 PIN	545-8281-028	2	U24,U25	LG	
9	IC SOCKET 40 PIN	545-8401-040	1	U10	LG	
10						
11						
12						
13						
14						
15						
16	DIODE, 1N4148	105-4148-000	1	D1	AXI	
17						
18						
19						
20	CAP, 10 UF, 35V	204-0106-135	3	C32,33,34	LG	.1-LS
21	CAP, 2.2 UF, 35V	206-0225-350	1	C2	LG	.1-LS
22	CAP, .01 UF, 50V	201-0103-050	14	C3-5,10,11,13,18,24-30	LG	.1-LS
23						
24	CAP, 33PF, 100V	201-0330-100	2	C14,15	LG	.1-LS
25	SWITCH,DIP,16 PIN SPST	450-4358-021	1	SP1	BW	
26	SWITCH,KEY,SPST MOMENTARY	450-1152-000	1	S1	LG	
27	SWITCH, DIP, 2 POS	450-7802-002	1	SP2	LG	
28	CRYSTAL, 8.0 MHZ	180-0080-020	1	Y2	LG	
29	RESISTOR, 47 OHM 1/4W 5%	303-0470-000	2	R8,13	AXI	
30	RESISTOR, 200K OHM 1/4W 5%	303-0204-000	1	R1	AXI	
31	RESISTOR, 100 OHM 1/4W 5%	303-0101-000	3	R16,17,18	AXI	
32	RESISTOR, 4.7K OHM 1/4W 5%	303-0472-000	4	R7,9,10,11	AXI	
33	RESISTOR, 1K OHM 1/4W 5%	303-0102-000	2	R14,R15	AXI	
34	RESISTOR, 10K OHM 1/4W 5%	303-0103-000	1	R12	AXI	
35	RESISTOR ARRAY, 10K OHM SIP	340-4310-103	6	RN1-6	LG	
36						

ITEM	DESCRIPTION	PART NUMBER	QTY.	REF. DESIG.	PROCESS CODE	PREP. CODE
37						
38						
39						
40	IC,CLOCK GENERATOR D82C284-8	070-8228-480	1	U2	DIP	
41	IC,MONOSTABLE,74LS122	074-74LS-122	1	U3	DIP	
42	IC,HEX INVERTER,74HCT14	074-74HT-014	1	U5	DIP	
43	IC,BUFFER,74LS541	074-74LS-541	4	U7,17-19	DIP	
44	IC,SRAM, 8K X 8	071-5564-015	1	U16 (H)	LG	
45	IC,BUS TRANS,74LS645	074-74LS-645	1	U20	DIP	
46	IC,Z80 CPU	070-8400-000	1	U10	AW	
47	EPROM, BLANK	071-2751-230	1	U24	AW	
48	LABEL, BLANK EPROM	550-0010-637	1		AW	
49	PAL, BLANK	071-8215-300	2	U23,26	AW	
50	LABEL, BLANK PAL	550-0017-619	2		AW	

SIGNATURES		DATE
DRAWN	SCHOLL	6-25-93
CHECKED	ALWARD	6-25-93
ENGR.	KLODOWSKI	6-25-93
PROJ. MGR.	YARZEBINSKI	6-29-93

SEE SHT. 1 FOR REV. LEVEL

MEDRAD® INC.
ONE MEDRAD DRIVE
INDIANOLA, PA 15051-0780

TITLE

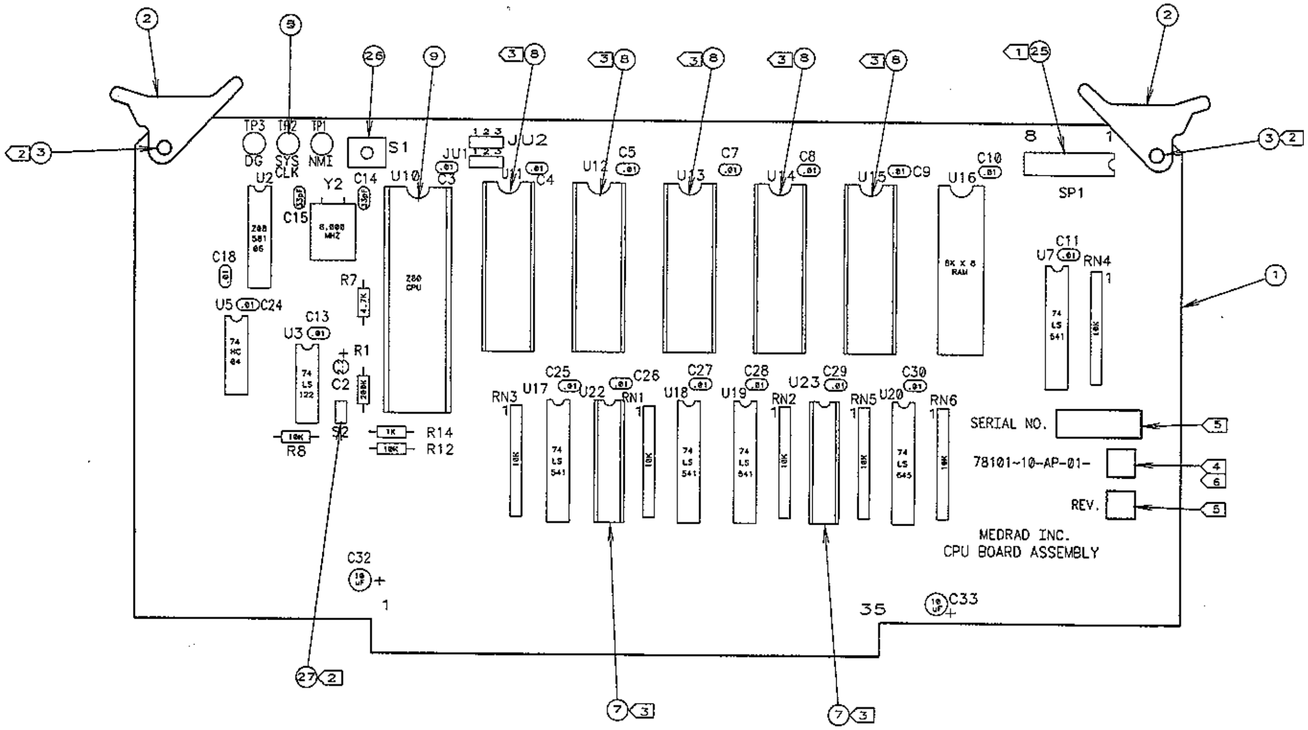
FINAL ASSEMBLY, CPU BOARD, MK V INJECTOR

DWG. NUMBER	REV.
78101-10-AP-14-3	J

DATE COPIED | SHEET 2 OF 2

REVISIONS

REV	ECO NO.	DESCRIPTION	DATE	APPVD.
A	DDN-126	ADDED C15, C17 TO PARTS LIST, CORRECTED C1, C8, C15 ON PARTS LIST. RELOCATED C8. ADDED U45. REV. NOTE F	3/21/86 TL	3/24/86 MGF
B	DDN-127	R14 WAS 18K	3/28/86 WAK	3/28/86 MGF
C	DDN-204	ITEM 5 QTY. WAS 6, DELETED NOTE H	2/13/87 JCB	2/17/87 AJY
D	DDN-282	ADDED CPU ID FOR U10	11/30/87 JCB	12/1/87 AJY
E	DDN-321	ADDED ITEMS 8,9, REV. NOTES F,I	5/11/88 JCB	5/12/88 AJY
F	DDN-346	REVISED NOTE F-2	7/6/88 JCB	6/7/88 JS
G	DDN-384	REVISED NOTE B	11/18/88 WAK	11/21/88 AJY
H	DDN-459	78101-00-PX-02 IN NOTE F1 WAS 78101-10-PX-02, CR 78101-10-98	5/2/89 JCB	5/2/89 AJY
I	DDN-508	REV NOTE A, CR 10000-NS-306	9/6/89 JCB	9/12/89 AJY
J	DDN-532	REV PROC. NO'S AT NOTES F, I ADDED NOTE H, CR10000-NS-158	11/3/89 JCB	11/8/89 AJY
K	DDN-565	CUT CONDUCTOR BETWEEN U3 PINS AND U3 PINS, CR 78101-10-107	1/17/90 BJD	1/17/90 AJY
L	DDN-686	REF. CR 10000-NS-495	6/22/90 JCB	7/6/90 THS
M	DDN-723	REV. PROC. COMPAT. CHART FOR S2 CR 78101-10-122	9/19/90 JCB	9/19/90 AJY
N	EC-11	REV. FOR MK V PLUS, REV. NOTES F,H	11/20/91 JCB	11/29/90 AJY
P	EC-239	REV. NOTE C FOR ALT. CIRCUIT HOLE SOLDER MASK	6/24/91 JCB	6/27/91 DPK
R	EC-393	REDRAWN ON CAD, ADD SHT. 2	8/2/91 MAW	9/12/91 DPK
S	EC-404	CORRECTED WRONG PART NUMBER	9/27/91 MAW	



NOTES:

1. LEAVE PLASTIC CAP ON SP-1 DURING WAVE SOLDER AND CLEANING REMOVE DURING TOUCH UP.
2. MASK COMPONENT LOCATIONS FOR PARTS MARKED "DO NOT WAVE SOLDER" PRIOR TO WAVE SOLDER. INSTALL PARTS MARKED "DO NOT WAVE SOLDER" AFTER WAVE SOLDER. HAND CLEAN ANY PARTS MARKED "DO NOT VAPOR DEGREASE" OR "DO NOT WATER WASH"
3. U11-U15, U22, AND U23 ARE INSTALLED AT A HIGHER LEVEL. COMPONENT DESIGNATORS ARE SHOWN FOR REFERENCE ONLY.
4. FINAL ASSEMBLY OF THIS CARD FOR STD. MARK V, MARK V PLUS AND MCT INJECTOR SYSTEMS IS AS NOTED BELOW:

INJECTOR SYSTEM	USE FINAL ASSY DWG.NO.
STANDARD MK V	78101-10-AP-01-2
MK V PLUS	78101-10-AP-01-3
MCT/MCT PLUS	78101-10-AP-01-4

5. SERIAL NO. AND REVISION TO BE APPLIED USING PERMANENT INK, OR PRE-PRINTED LABEL (ITEM 6)
6. T/A TO FILL IN BOARD P/N BLOCK DURING BOARD CALIBRATION TEST.

PROCESS COMPATABILITY CHART

ITEM/DESIG.	DO NOT WAVE SOLDER	DO NOT VAPOR DEGREASE	DO NOT WATER WASH
2,3	X		
S2	X	X	X

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MEDRAD INC.
271 KAPPA DRIVE
PITTSBURGH, PA 15238

TITLE: MK V/MCT INJECTOR (20K SERIES) C.P.U. BOARD ASSEMBLY

SIZE: D | DWG. NUMBER: 78101-10-AP-01-1 | REV: S

SCALE: 2X | SHEET 1 OF 2

BILL OF MATERIAL

ITEM	DESCRIPTION	PART NUMBER	QTY.	REF. DESIG.	PROCESS CODE	PREP. CODE
1	PC CARD, REV. H AND UP	78101-10-PC-01	1		LG	
2	CARD EJECTOR, WHITE	510-7000-000	2		AW	
3	CARD EJECTOR PIN	510-7001-000	2		AW	
4						
5	TUBULAR TERMINAL	642-1238-000	3	DG,SYS CLK,NMI	BW	
6	LABEL, BLANK SERIAL NO	550-0093-652	1		BW	NOTE 5
7	IC SOCKET, 20 PIN	545-8201-020	2	U22,U23	LG-016	
8	IC SOCKET, 28 PIN	545-8281-028	5	U11,U12,U13,U14,U15	LG-002	
9	IC SOCKET 40 PIN	545-8401-040	1	U10	LG-014	
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20	CAP, 10 UF, 35V	204-0106-135	2	C32,33	LG-009	.1-LS
21	CAP, 2.2 UF, 35V	206-0225-350	1	C2	LG-015	.1-LS
22	CAP, .01 UF, 50V	201-0103-050	17	C3-5,7-11,13,18,24-30	LG-019	.1-LS
23						
24	CAP, 33PF, 100V	201-0330-100	2	C14,15	LG-012	.1-LS
25	SWITCH,DIP,16 PIN SPST	450-4358-021	1	SP1	LG-021	
26	SWITCH,KEY,SPST MOMENTARY	450-1152-000	1	S1	LG-020	
27	SWITCH,SPST	450-4356-651	1	S2	BW	
28	CRYSTAL, 8.0 MHZ	180-0080-020	1	Y2	LG-011	
29						
30	RESISTOR, 200K OHM 1/4W 5%	303-0204-000	1	R1	LG-003	5BEND
31	RESISTOR, 10K OHM 1/4W 5%	303-0103-000	2	R8,12	LG-001	5BEND
32	RESISTOR, 4.7K OHM 1/4W 5%	303-0472-000	1	R7	LG-007	5BEND
33	RESISTOR, 1K OHM 1/4W 5%	303-0102-000	1	R14	LG-005	5BEND
34						
35	RESISTOR ARRAY, 10K OHM SIP	340-4310-103	6	RN1-6	LG-017	5BEND
36						

ITEM	DESCRIPTION	PART NUMBER	QTY.	REF. DESIG.	PROCESS CODE	PREP. CODE
37						
38						
39						
40	IC,CLOCK CONTROLLER,Z8581	070-8581-000	1	U2	LG-008	
41	IC,MONOSTABLE,74LS122	074-74LS-122	1	U3	LG-013	
42	IC,HEX INVERTER,74PC04	080-74PC-004	1	U5	LG-010	
43	IC,BUFFER,74LS541	074-74LS-541	4	U7,17-19	LG-004	
44	IC,SRAM, 8K X 8	071-8464-000	1	U16	LG-018	
45	IC,BUS TRANS,74LS645	074-74LS-645	1	U20	LG-006	
46	IC,Z80 CPU	070-8400-000	1	U10	AW	

SIGNATURES	DATE
DRAWN	
CHECKED	
ENGR.	
PROJ. MGR.	

SEE SHT. 1 FOR REV. LEVEL

MEDRAD INC.
271 KAPPA DRIVE
PITTSBURGH, PA 15238

TITLE
MKV/MCT INJECTOR (20K SERIES)
CPU BOARD ASSEMBLY

DWG. NUMBER 78101-10-AP-01-1 REV. S

DATE COPIED

SHEET 2 OF 2

7 Input / Output Card

Through the I/O Card, the CPU:

- reads Control Panel, external switches, and system event status
- operates Control Panel displays and external connections
- synchronizes and times the injection.

Refer to page 7 - 3 for a block diagram of the I/O Card.

Bus Buffers

The control bus is buffered by U14, and the address bus is buffered by U15. The bidirectional data bus is buffered and controlled by U22, with direction control from I/O decoder U8.

Display Decoder

Signals for the Control Panel Display Card are provided by 4-16 channel decoder U1, while U7 inserts display driver "Wait States". These signals control the Sentinel and LED display drivers.

Display Buffers

Two address lines, and eight data lines, are buffered for the Display Card by U16 and U19.

I/O Decoder

Decoder U8, controlled by address and control lines, provides an enable to programmable I/O (PIO) chips U5 and U6, counter/timer chip (CTC) U4, and, provides data direction control for data buffer U22.

Parallel Input/Output Chips

Parallel I/O chips permit the CPU to access external inputs, and to control outputs.

- PIO1 – The inputs to U6 are the hand start switch, remote start switch, and remote disarm input. Through the data buses, the CPU can check the digital status of these inputs. Outputs from U6 include: The film changer relay enable, two injecting signals, Armed signal, and Head Indicator signals. Through the I/O chip, the CPU can turn these outputs on and off.

- PIO2 – This device (U5) is dedicated to decoding of the keypad on the Control Panel. Port A (sense line) rotates a Logic-0 on each line on the keypad matrix. When a key is pressed, one line of Port B will go to Logic-0. The CPU compares Port A to Port B to determine which key was pressed.

Port A lines A0 - A3:	for the Main Keypad
Port A lines A4 - A7:	for the ECG/Scope Keypad

Counter / Timer Chip (CTC)

The CTC (U4) generates interrupt signals for the CPU. The interrupts are prioritized and asynchronous with the system clock.

- Trigger 0: (Not used with SYS 500-PI, or RMT 505-PI/510-PI) R-wave detector interrupt request. When an R-wave is detected, an interrupt is generated. Trigger 0 has the highest priority and is used only with the ECG option.

- Trigger 1: PPI memory error interrupt request. PPI primary and backup memories are compared each time primary memory is read. If primary and backup data values are not equal, an interrupt request is generated.

- Trigger 2: UART (Universal Asynchronous Receiver-Transmitter) interrupt request. This indicates that the Remote Panel is requesting communication with the Main Unit.

- Trigger 3: Timed Interrupt. This provides a real-time clock and delay timer function. During an injection, this interrupt program performs Flow Rate and Volume Limit calculations. This interrupt is not externally triggered, but driven from the time divided clock generator.

Test Decoder

This 4-16 channel decoder (U2) provides Reset pulses for Watchdog 1, and controls timing of the buzzer.

Test Section

The circuit surrounding U17 and U18 is for in-house testing.

ECG Detector

This circuitry is used only with the ECG option. The incoming R-wave signal is sent to the multiplying DAC circuit (U20, U21, U23, and U24 or U20, U21, and U26), while sensitivity to this signal is controlled by the Gain Up/Down keys on the ECG Keypad. Gain information is sent through the data bus to U20, which sets a multiplication factor for DAC U21. The output of the DAC is buffered (at U24 or U26A), then sent to the R-wave detector U23 or U26B, of which output is a pulse that indicates an R-wave. This pulse goes through a pulse shaping network (U25 or U27), then to CTC Trigger 0.

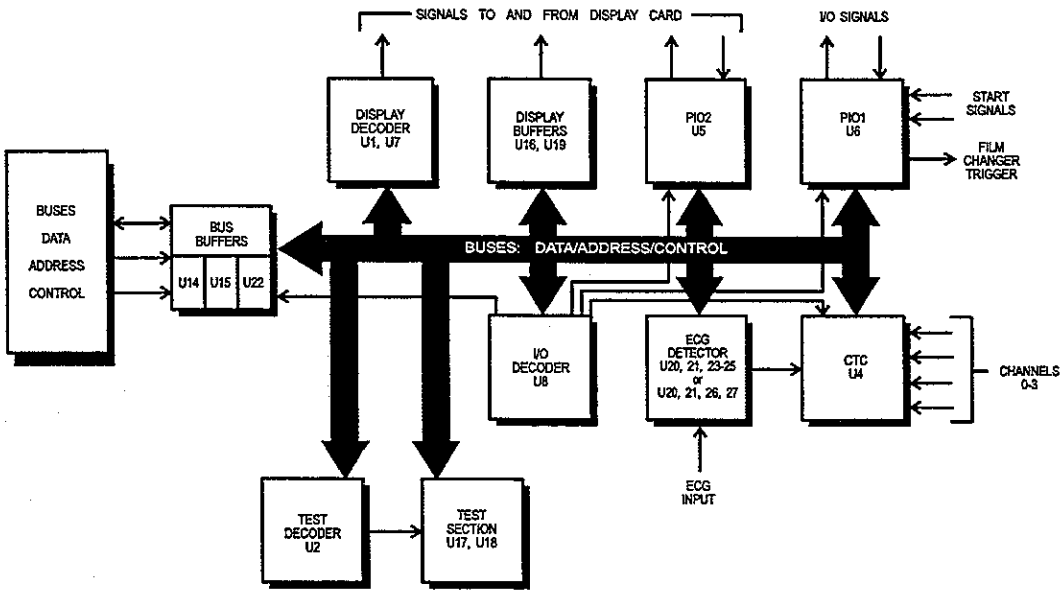
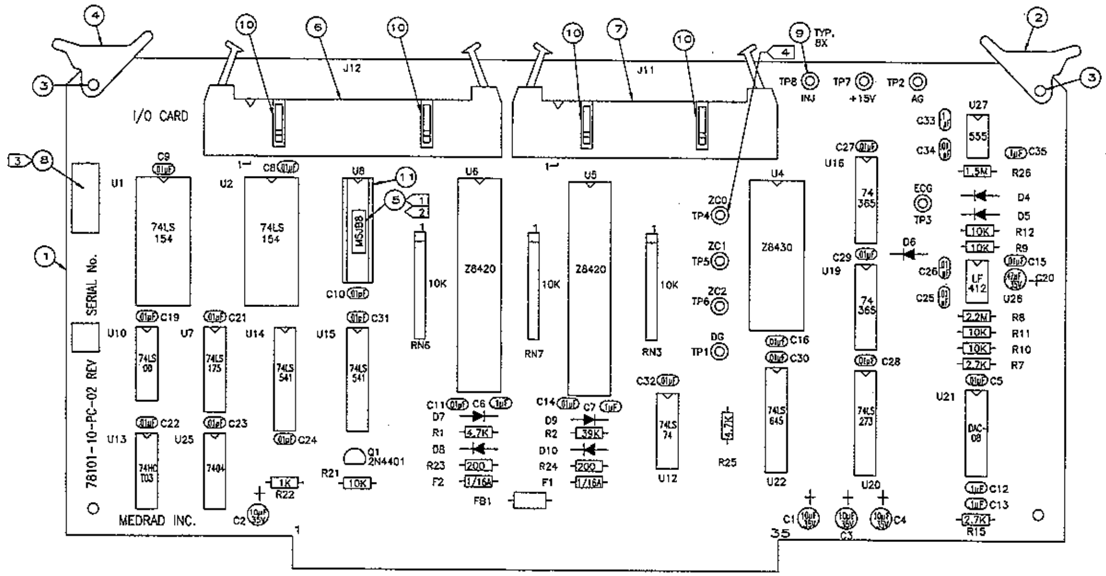


Figure 7.1: Block Diagram: I/O Card

NOTES:

REVISIONS

REV	ECO NO/EC NO	DESCRIPTION	CHK BY/DATE	APPVD.
AB	EC-2719	CAD REGENERATED, SEE REV AA FOR PRIOR REVS, REVISED NOTES	SWB 6-16-97	



5. MASK COMPONENT LOCATIONS FOR PARTS MARKED "DO NOT WAVE SOLDER" PRIOR TO WAVE SOLDER. INSTALL PARTS MARKED "DO NOT WAVE SOLDER" AFTER WAVE SOLDER. HAND CLEAN ANY PARTS MARKED "DO NOT WATER WASH".

PROCESS COMPATABILITY CHART		
ITEM/DESIG.	DO NOT WAVE SOLDER	DO NOT WATER WASH
2, 3, 4	X	

4. ORIGIN LOCATION, TP4

3. SERIAL NO. TO BE APPLIED USING PERMANENT INK, SCRIBE OR PRE-PRINTED LABEL (ITEM 11).

1. SEE INSTUCTIONS FOR PROGRAMMING U8 ON DOC. NO. 94064-00-PX-01 PRIOR TO INSTALLATION. (UNPROGRAMMED PT. NO. FOR U8 IS 071-8215-300 PROGRAMMED PT. NO. IS M5JB8) PAL LABELS ARE TO BE ATTACHED AFTER PROGRAMMING

NOTES:

SIGNATURES	DATE
JCB	3-6-84
TROCK	5-3-84
RHP	6-15-84
	N/A

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MEDRAD® INC.
ONE MEDRAD DRIVE
INDIANOLA, PA 15051-0780

TITLE: MKV INJECTOR I/O BOARD ASSEMBLY

SIZE: D DWG. NUMBER: 78101-10-AP-02 REV. AB

SCALE: NTS SHEET 1 OF 2

BILL OF MATERIAL

ITEM	DESCRIPTION	PART NUMBER	QTY.	REF. DESIG.	PROCESS CODE	PREP. CODE
1	PC CARD, (REV 0 & UP)	78101-10-PC-02	1		LG	
2	CARD EJECTOR, WHITE	510-7000-000	1		AW	
3	CARD EJECTOR PIN	510-7001-000	2		AW	
4	CARD EJECTOR, VIOLET	510-7003-000	1		AW	
5	IC, LABEL, BLANK PAL	550-0017-619	1	U8	AW	NOTE 1
6	CONNECTOR, 40 PIN HEADER	518-0208-040	1	J12	BW	
7	CONNECTOR, 34 PIN HEADER	518-0208-034	1	J11	BW	
8	LABEL, BLANK SERIAL NUMBER	550-0093-652	1		BW	NOTE 3
9	TUBULAR TERMINAL	642-1238-000	8	AC,DC,BECC,ZC0,ZC1,ZC2,+15,IN	BW	
10	POLARIZING KEY	518-3518-000	4	J11,J12	BW	
11	IC SOCKET, 20 PIN	545-8201-020	1	U8	LG	
12	FERRITE BEAD	280-1625-000	1	FB1	LG	5 BEND
13	CAPACITOR, 10µF, 35V	204-0106-135	4	C1,C2,C3,C4	LG	.1-LS
14	CAPACITOR, .47µF, 35V	206-0474-350	1	C20	LG	.1-LS
15	CAPACITOR, .01µF, 50V	201-0103-050	22	C5,C8-C11,C14-C16,	LG	.1-LS
				C19,C21-C32,C34		
16	CAPACITOR, .1µF, 50V	201-0104-050	6	C6,C7,C12,C13,C33,C35	LG	.1-LS
17	FUSE, 1/16A, PICO	476-0062-000	2	F1,F2	LG	5 BEND
18	TRANSISTOR, 2N4401	120-4401-000	1	Q1	BW	
19	DIODE, 1N4148	105-4148-000	7	D4-D10	AXI	
20	RESISTOR, 2.7 KOHM, 1/4W, 5%	303-0272-000	2	R7,R15	AXI	
21	RESISTOR, 10 KOHM, 1/4W, 5%	303-0103-000	5	R9-R12,R21	AXI	
22	RESISTOR, 2.2 MOHM, 1/4W, 5%	303-0225-000	1	R8	AXI	
23	RESISTOR, 200 OHM, 1/4W, 5%	303-0201-000	2	R23,R24	AXI	
24	RESISTOR, 1 KOHM, 1/4W, 5%	303-0102-000	1	R22	AXI	
25	RESISTOR, 4.7 KOHM, 1/4W, 5%	303-0472-000	2	R1,R25	AXI	
26	RESISTOR, 39 KOHM, 1/4W, 5%	303-0393-000	1	R2	AXI	
27	RESISTOR, 1.5 MOHM, 1/4W, 5%	303-0155-000	1	R26	AXI	
28	RESISTOR ARRAY, 10 KOHM, SIP	340-4310-103	3	RN3,RN6,RN7	LG	
29	IC, 4-16 DECODER, 74LS154	074-74LS-154	2	U1,U2	LG	
30	IC, PIO, Z8420	070-8420-000	2	U5,U6	LG	
31	IC, CTC, Z8430	070-8430-000	1	U4	LG	
32	IC, BUS TRANS, 74LS645	074-74LS-645	1	U22	DIP	
33	IC, BUFFER, 74LS541	074-74LS-541	2	U14,U15	DIP	
34	IC, QUAD NAND GATE, 74LS00	074-74LS-000	1	U10	DIP	
35	IC, D FLIP-FLOP, 74LS175	074-74LS-175	1	U7	DIP	
36	IC, QUAD QC NAND, 74HCT03	074-74HT-003	1	U13	DIP	
37	IC, HEX INVERTER, 74PC04	080-74PC-004	1	U25	DIP	
38	IC, OP-AMP, LF412	050-0412-000	1	U26	DIP	
39	IC, D FLIP-FLOP, 74LS74	074-74LS-074	1	U12	DIP	
40	IC, OCTAL D F-F, 74LS273	074-74LS-273	1	U20	DIP	
41	IC, D/A CONV, DAC-08	126-0008-000	1	U21	DIP	
42	IC, HEX BUFFER, 74365	074-7436-005	2	U16,U19	DIP	
43	IC, TIMER, 555	053-0555-050	1	U27	DIP	
44	IC, PAL, BLANK	071-8215-300	1	U8	AW	
45						
46						
47						
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50						
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53						
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58						
59						
60						
61						

SIGNATURES		DATE
DRAWN	B.J. O'HELLA	10-26-90
CHECKED	A.J. YARZEBINSKI	10-29-90
ENGR.	T.H. BRAUNSTEIN	10-29-90
PROJ. MGR.	N/A	

SEE SHT. 1 FOR REV. LEVEL

MEDRAD® INC.
ONE MEDRAD DRIVE
INDIANOLA, PA 15051-0780

TITLE

MK V INJECTOR
I/O BOARD ASSEMBLY

DWG. NUMBER 78101-10-AP-02 REV. AB

DATE COPIED

SHEET 2 OF 2

8 Servo Control Card

The Servo Control Card (SCC) serves two primary functions:

- Provide signals that control the Flow Rate and Power Drive circuits
- Read and interpret information from the head, to control injection Flow Rate and Pressure [limit].

Refer to the figure on page 8 - 4 for a block diagram of the Servo Control Card.

Bus Buffers

The control bus is buffered by U12, and the address bus is buffered by U11. The bi-directional data bus is buffered and controlled by U10, with direction control coming from direction logic.

Direction Logic

Gates U7-U9 control the direction line of U10, controlling the flow of data to and from the card.

A/D Converter

Analog-to-digital (A/D) converter U1 inputs a multiplexed analog signal, and converts it into a digital word. This process is controlled by A/D converter logic (U4, U5) and DAC decoder U14. When requested from the CPU, the converted 10-bit value is gated to the data bus by tri-state buffers U2 and U3.

A/D Converter Logic

Gates U4 and U5 control the A/D converter U1, starting the A/D conversion when the data is ready, and enabling buffers U2 and U3 to transfer the converted word to the data bus.

DAC Decoder

Decoder U14, with U18 and U6, provide enable signals for the DACs (digital-to-analog converters) and the MUX (multiplexer). These enables allow data bus information to be written to the device. The decoder also provides signals for the A/D converter logic, direction logic, and Reset pulses for WATCHDOG 2.

WATCHDOG 2

The DAC decoder sends pulses to WATCHDOG 2 (U15) when the mechanical stop is in position, and "Ready to Inject". If the Mechanical Stop takes too long to move into position, the pulses from the DAC decoder will stop, resulting in a disarm condition. The Sentinel will then display the message "Mechanical Stop Position Failure".

PIO3

The inputs to PIO3 (U16) are signals from the Injector Head, Power Drive Circuit, and the analog portion of the SCC. These inputs include: Turret switch position, 60 ml indication, and FWD/REV indication from the Injector Head, Aux Monitor from the PDC, and an Overpressure Limit signal from the SCC. The status of PIO3 inputs are

directed to the CPU through data busses. Outputs from PIO3 include: Flow Control signals, the Safe Relay Enable, and the System Override signal.

System Monitor Flip-Flop

The flip-flop (U17) sends alarm signals to disarm the injector, if any of the following input conditions occur: WATCHDOG 2, OPLIM (overpressure signal), or AUX MONITOR (power drive failure).

Command, Position, and Signal DACs

When enabled and timed by the DAC decoder U14, one of the DACs (U21-U24) will read a byte of data bus information. The DAC then converts the byte to an analog voltage between zero and 10 VDC. DAC resolution is 40mV per count.

Pressure Limit Command DAC
The output of this DAC is the Pressure Limit Command signal (PSILIM SELECTED). This signal is sent to the Multiplexer, the Primary Pressure Limit circuit, and the Overpressure Limit circuit.

Flow Rate Command DAC
The output of this DAC is the Flow Rate Command signal (FLOW RATE SELECTED). This signal is sent to the Multiplexer, Flow Scale Circuit and Power Drive Card (PDC, PDCP, or PDCI).

Mechanical Stop Position DAC
The output of this DAC is the Mechanical Stop Position signal (MSPOSCMD). This signal is sent to the Multiplexer, and through Unity Gain Buffer U26C, to the Mechanical Stop Drive Card.

Velocity Signal DAC
The output of this DAC is a digitized velocity signal, sent to the Imaging System Interface Card. This signal is buffered, becoming the Flow Profile Signal available through connector J15, pin 4.

Multiplexer (MUX)

The multiplexer circuit is comprised of multiplexer U19, Quad latch U20, and Unity-Gain buffer U26A. This circuit receives eight inputs, and under timing control connects each input to the circuit output, which is sent to the A/D converter.

TTL/CMOS Converter

U25 converts TTL logic (0/5V) to CMOS logic (0/15V).

10V Reference

Chip U28 develops +10 VDC as a reference voltage for the Plunger and Mechanical Stop position feedback pots in the head. This voltage is also applied to the multiplexer to be monitored by the CPU.

Pot Processor

This circuit, comprised of U27C and associated components, buffers and filters the pot wiper signal. The pot signal is an input to the multiplexer and the error amplifier.

Primary Pressure Limit Circuit

The Primary pressure limit circuit (U26B), compares the pressure limit command to the actual pressure developed during an injection. The

output of this circuit is sent to three Pressure Limiting circuits to perform the following functions:

Flow Rate Integrator Circuit U29.
The output of U26B is summed with the Flow Rate command to effectively reduce the input voltage to U29. This action results in the reduction of the Flow Rate command signal, thereby preventing the selected pressure limit from being exceeded.

Inverting amplifier, U27B.
The output of this amplifier is summed with the output of the Main Flow Integrator, to reduce the voltage sent to the error amplifier U27D, thereby decreasing the error signal.

Circuit Q4.
This circuit is driven to cut-off, sending a pressure limit indication signal (PRESLIMIND) to PIO3 (U16), and eventually to the CPU. This PRESLIMIND signal will also send Q12 into a saturation state, which shunts R81 and reduces the gain of the error amplifier, thereby decreasing the error signal.

Overpressure Circuit

If the actual pressure exceeds the pressure limit command by greater than 100-150 PSI, the Overpressure Circuit (U26D) forwards an OPLIM signal to stop the injection.

Flow Scale Circuit

Using the two flow scale signals, circuits Q5, Q6, and Q11 attenuate the flow rate selected signal during ML/MIN and ML/HR flow scale injections.

Standby Reset Circuit

Driven by the INJECT signal, Q8, Q9, and Q10 control the flow rate integrator, U29. During standby, the integrator follows the position pot. The output of the integrator is equal in amplitude, and opposite in polarity to the position pot. When an injection is to occur, this circuit allows U29 to generate the position command.

Flow Rate Integrator

The master position command is generated by integrator U29. The output of this circuit is a ramp, with a slope proportional to the input signal (flow rate selected).

Error Amplifier

When the plunger is moving at the desired flow rate, the master position command from U29 and the pot wiper signal from U27C are equal but opposite in polarity. The output of error amplifier U27D is the difference between these two signals, or the position error. This error signal is used by the drive circuits to power the motor. If pressure limiting occurs, a signal from U27B reduces the error signal, and the gain of U27D is reduced by Q12.

Feed Forward Circuit

This circuit, comprised of Q7 and U27A, provides a boost voltage to the motor to compensate for the internal resistance of the motor. This turning voltage varies with the Flow Rate.

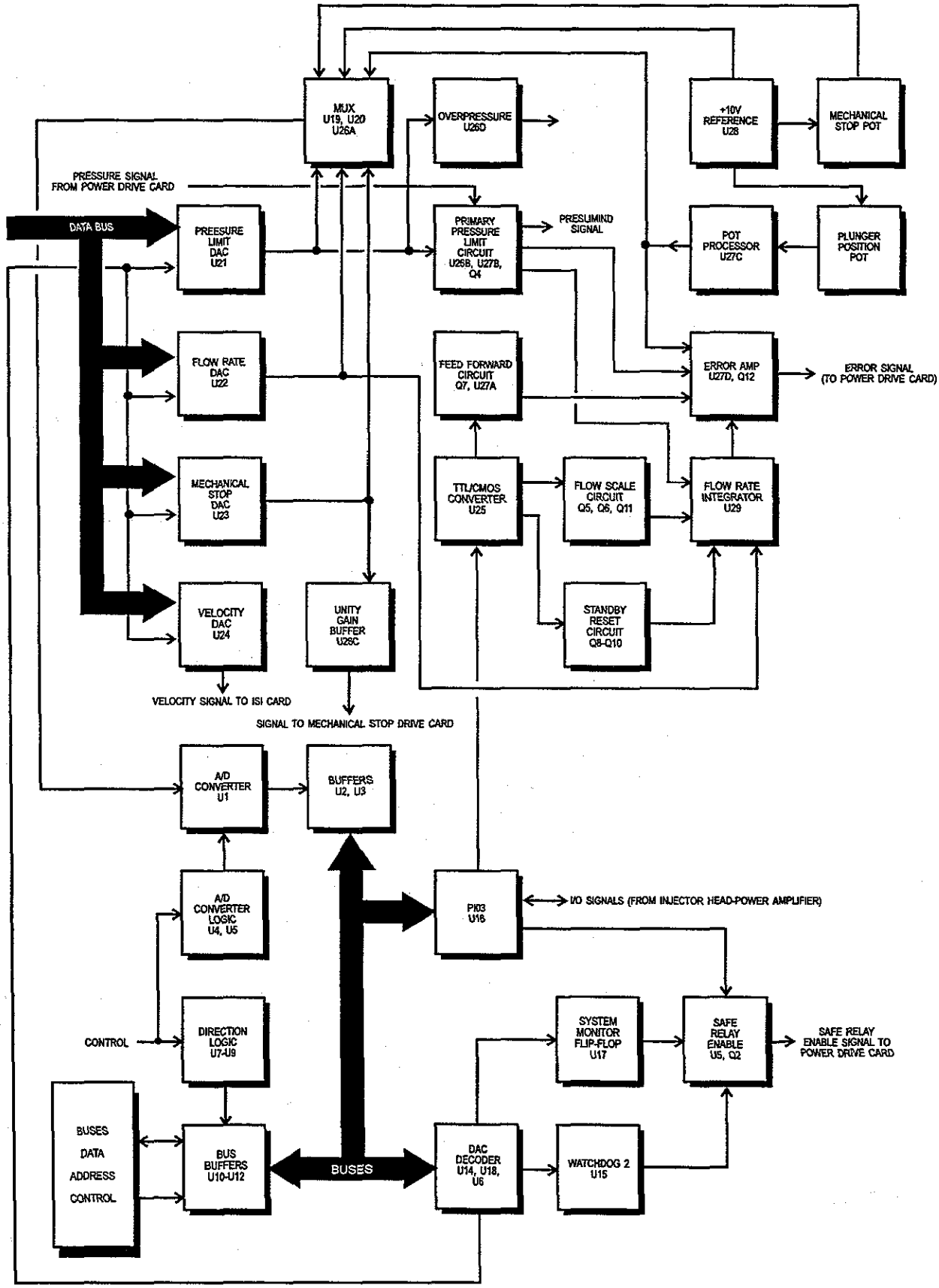
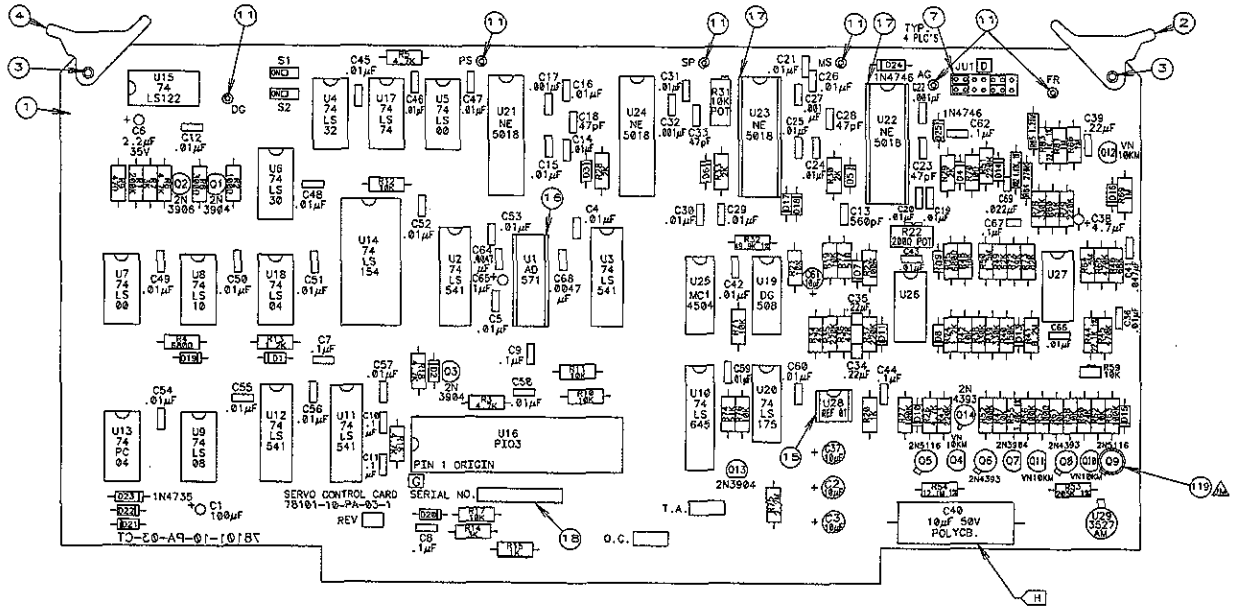


Figure 8.1: Block Diagram: Servo Control Card

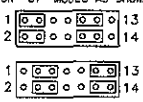
REVISIONS				
REV	ECO NO.	DESCRIPTION	DATE	APPVD
G	EC-631	RELEASED FOR SVC. MANUAL CLARITY. SEE REV. FF FOR PRIOR REVISIONS.	3/13/92 TJM	3/18/92 RAK
HH	EC-998	ADDED NOTE H.	1-6-93 MJA	1-6-93 AJY
J	EC-1048	ADDED ITEMS 118 & 117. PROCESS CODE CHANGES. ST. 78 QTY. WAS 3, IT. 53 QTY. WAS 6.	2-26-93 SCS	2-26-93 DPK
JK	EC-1150	REL. 3F, 5, DEL. 1029 FROM PROCESS COMPATABILITY CHART. CHANGE PROCESS CODE IV, 17. REVISION PRACTICE CHANGE.	5-2-93 SCS	5-3-93 DPK
JL	EC-1790	GENERAL REVISIONS	5-8-93 SCS	5-17-93 AJY
JM	EC-2186	ADDED ITEM 119	1-27-94 SCS	



A INSTALL COMPONENTS MARKED 'DO NOT WAVE SOLDER' AFTER WAVE SOLDER. HAND CLEAN COMPONENTS MARKED RDO NOT WATER WASH'. MASK ALL COMPONENT LOCATIONS MARKED 'DO NOT WAVE SOLDER'.

B ALL UNMARKED DIODES 1N4148.

D INSTALL PROGRAMMING SHUNT (ITEM 7) AS DETAILED ABOVE FOR JUMPER JU1 DURING ASSEMBLY. T/A WILL SET PROGRAMMING SHUNTS DURING TEST AS REQUIRED TO THE 'AP' OR 'CT' MODES AS SHOWN BELOW:



E PRODUCTION TO FILL IN REV BLOCK USING PERMANENT INK WITH THE ASSEMBLY DRAWING REVISION TO WHICH THE BOARD WAS BUILT. SERIAL NO. BLOCK TO BE FILLED USING PERMANENT INK OR LABEL (ITEM 18).

F ALL SOCKETED COMPONENTS TO BE INSTALLED AFTER WAVE SOLDER.

G LOCATION MARKED 'G' IS USED TO INDICATE ORIGIN LOCATION (U16 PIN1).

⚠H USE ADHESIVE TO FASTEN C40 TO THE BOARD. USE RTV OR EQUIVALENT REMOVABLE SILICON BASED ADHESIVE.

⚠ PROCESS COMPATABILITY CHART

ITEM DESIG.	DO NOT WAVE SOLDER	DO NOT WATER WASH
6	X	X
20	X	

GEOMETRIC TOLERANCES		STANDARD STENCILLED	UNLESS OTHERWISE SPECIFIED	SIGNATURES	DATE
SYMBOL	CHARACTERISTIC			DRAWN JCB	2/24/84
				DESIGN AJY	7/6/84
				ENGR. JS	7/9/84
				MFG. YARZEBINSKI	3/18/92
				DO NOT SCALE DRAWING	

MEDRAD, INC.
271 KAPPA DRIVE
PITTSBURGH, PA 15238

TITLE
MKV MCT INJECTOR
SERVO CONTROL CARD ASSEMBLY

SIZE D | DWG. NUMBER 78101-10-AP-03-1 | REV JM

SCALE NTS | SHEET 1 OF 3

BILL OF MATERIAL

ITEM	DESCRIPTION	PART NUMBER	QTY.	PROCESS CODE	PREP CODE	REF. DESIG
1	PC CARD (REV L AND UP)	78101-10-PC-03	1	LG		
2	CARD EJECTOR (WHITE)	510-7000-000	1	AW		
3	CARD EJECTOR PIN	510-7001-000	2	AW		
4	CARD EJECTOR (GREEN)	510-7004-000	1	AW		
5						⚠JK
6	SWITCH, SPST	450-4356-651	2	AW		S1,2
7	PROGRAMMING SHUNT	518-5312-202	4	AW		NOTE B
10	HEADER, 14 PIN	500-1070-700	1	BW		JU1
11	TUBULAR TERMINAL	642-1238-000	6	BW		
15	IC SOCKET, 8 PIN	545-0008-000	1	LG		U28
16	IC SOCKET, 18 PIN	545-8181-018	1	LG		U1
17	IC SOCKET, 22 PIN	545-8221-022	2	LG		U22,23
18	LABEL, BLANK SERIAL NUMBER	550-0093-652	1	BW	NOTE E	
20	CAP, 10uf 50V POLYCARBONATE	209-0106-500	1	AW	14 BEND	C40
21	CAP, 560pF, 50V	201-0561-050	1	LG	.1-LS	C13
22	CAP, .047uf, 50V	201-0473-050	1	LG	.1-LS	C41
23	CAP, .0047uf, 50V	201-0472-050	2	LG	.1-LS	C64,68
24	CAP, .022uf, 50V	201-0223-050	1	LG	.1-LS	C69
25	CAP, 47PF, 50V	201-0470-050	4	LG	.1-LS	C18,23,28,33
26	CAP, .001uf, 50V	201-0102-050	4	LG	.1-LS	C17,22,27,32
27	CAP, .22uF, 50V	201-0224-050	3	LG	.1-LS	C34,35,39
28	CAP, .1uf, 50V	201-0104-050	8	LG	.1-LS	C7,8,9,10,11,44,62,67
29	CAP, .01uf, 50V	201-0103-050	35	LG	.1-LS	C4,5,12,14-16,19-21,24-26,29-31,36,42,43,45-60,66
30	CAP, 2.2uf, 35V	206-0225-350	1	LG	.1-LS	C6
31	CAP, 100uf, 10V	204-0107-010	1	LG	.1-LS	C1
32	CAP, 1uf, 35V	206-0105-350	1	LG	.1-LS	C65
33	CAP, 10uf, 35V	206-0106-351	4	LG	.1-LS	C2,3,37,61
34	CAP, 4.7uf, 35V	206-0475-350	1	LG	.1-LS	C38
40	TRANSISTOR, 2N3904	120-3904-000	4	BW		Q1,3,7,13
41	TRANSISTOR, 2N3906	121-3906-000	1	BW		Q2
42	TRANSISTOR, FET, VN10KM	019-0010-000	4	BW		Q4,10,11,12
43	TRANSISTOR, 2N5116	175-5116-000	2	BW		Q5,9
44	TRANSISTOR, FET, 2N4393	175-4393-000	3	BW		Q6,8,14
45	DIODE, 1N4148	105-4148-000	19	AXI		D1-11,13-20
46	DIODE, ZENER, 1N4735, 6.2V	102-4735-100	1	BW	5 BEND	D23
47	DIODE, ZENER, 1N4746, 18V	102-4746-100	2	BW	5 BEND	D24,D25

ITEM	DESCRIPTION	PART NUMBER	QTY.	PROCESS CODE	PREP CODE	REF. DESIG
50	RESISTOR, 47 OHM 1/4 W 5%	303-0470-000	1	AXI		R9
51	RESISTOR, 200 KOHM 1/4 W 5%	303-0204-000	1	AXI		R1
52	RESISTOR, 3 KOHM 1/4 W 5%	303-0302-000	2	AXI		R7,14
53	RESISTOR, 4.7 KOHM 1/4 W 5%	303-0472-000	5	AXI		R3,5,6,18,26
54	RESISTOR, 300 KOHM 1/4 W 5%	303-0301-000	1	AXI		R8
55	RESISTOR, 100 OHM 1/4 W 5%	303-0101-000	2	AXI		R2,57
56	RESISTOR, 680 OHM 1/4 W 5%	303-0681-000	2	AXI		R4,25
57	RESISTOR, 1.2 KOHM 1/4 W 5%	303-0122-000	2	AXI		R13,24
58	RESISTOR, 10 KOHM 1/4 W 5%	303-0103-000	13	AXI		R10,11,12,17,19,21,42,47,58,61,62,71,76
59	RESISTOR, 1 KOHM 1/4 W 5%	303-0102-000	2	AXI		R15,20
60	RESISTOR, 2 KOHM 1/4 W 5%	303-0202-000	4	AXI		R28,29,30,33
61	RESISTOR, 10 OHM 1/4 W 5%	303-0100-000	1	AXI		R70
62	RESISTOR, 220 KOHM 1/4 W 5%	303-0224-000	5	AXI		R35,37,43,51,79
63	RESISTOR, 100 KOHM 1/4 W 5%	303-0104-000	5	AXI		R23,27,52,56,63
64	RESISTOR, 51 OHM 1/4 W 5%	303-0510-000	1	AXI		R77
65	RESISTOR, 49.9 KOHM 1%	313-4992-000	1	AXI		R32
66	RESISTOR, 4.02 KOHM 1%	313-4021-000	1	AXI		R82
67	RESISTOR, 270 OHM 1/4 W 5%	303-0274-000	1	LG		R84
68	RESISTOR, 1.21 MOHM 1%	313-1214-000	1	AXI		R85
69	RESISTOR, 22.1 KOHM 1%	313-2212-000	2	AXI		R44,83
70	RESISTOR, 1 MOHM 1/4 W 5%	303-0105-000	2	AXI		R69,81
71	RESISTOR, 51 KOHM 1/4 W 5%	303-0513-000	2	AXI		R74,80
72	RESISTOR, 330 KOHM 1/4 W 5%	303-0334-000	3	AXI		R38,39,78
73	RESISTOR, 150 KOHM 1/4 W 5%	303-0154-000	1	AXI		R40
74	RESISTOR, 8.2 MOHM 1/4 W 5%	303-0825-000	1	AXI		R41
75	RESISTOR, 470 KOHM 1/4 W 5%	303-0474-000	2	AXI		R45,65

SIGNATURES		DATE
DRAWN	WHALEN	9-13-90
CHECKED	A. YARZEBINSKI	9-25-90
ENGR.	T. BRAUNSTEIN	9-26-90
PROJ. MGR.	YARZEBINSKI	3-18-92

SEE SHT. 1 FOR REV. LEVEL

MEDRAD INC.
271 KAPPA DRIVE
PITTSBURGH, PA 15238

TITLE

MARK V INJECTOR SERVO CONTROL CARD ASSEMBLY

DWG. NUMBER 78101-10-AP-03-1 REV. JM

DATE COPIED

SHEET 2 OF 3

BILL OF MATERIAL

ITEM	DESCRIPTION	PART NUMBER	QTY.	PROCESS CODE	PREP CODE	REF. DESIG
76	RESISTOR, 68 KOHM 1/4 W 5%	303-0683-000	1	AXI		R46
77	RESISTOR, 1.5 MOHM 1/4 W 5%	303-0155-000	2	AXI		R50,64
78	RESISTOR, 82 KOHM 1/4 W 5%	303-0823-000	1	AXI		R73
79	RESISTOR, 39 KOHM 1/4 W 5%	303-0393-000	1	AXI		R72
80	RESISTOR, 62 KOHM 1/4 W 5%	303-0623-000	1	AXI		R49
81	RESISTOR, 56 KOHM 1/4 W 5%	303-0563-000	1	AXI		R48
82	RESISTOR, 47 KOHM 1/4 W 5%	303-0473-000	2	AXI		R34,36
83	RESISTOR, 24 KOHM 1/4 W 5%	303-0243-000	1	AXI		R60
84	RESISTOR, 3.48 KOHM 1%	313-3481-000	1	AXI		R55
85	RESISTOR, 2.2 MOHM 1/4 W 5%	303-0225-000	1	AXI		R75
86	RESISTOR, 12.1 MOHM 1%	315-1215-000	1	AXI		R54
87	RESISTOR, 205 KOHM 1%	313-2053-000	1	AXI		R53
88	POT, 200 OHM 1 TURN	353-0201-010	1	LG		R22
89	POT, 10 KOHM, 25 TURN	362-0103-010	1	LG		R31
90	POT, 10 KOHM 1 TURN	353-0103-010	1	LG		R59
95	IC, A/D CONV, AD571	050-0571-000	1	AW		U1
96	IC, VOLTAGE REF, REF-01	052-4101-000	1	AW		U28
97	IC, PRECISION OP AMP, 3527AM	050-3527-070	1	BW		U29 ⚠K
98	IC, MONOSTABLE, 74LS122	074-74LS-122	1	DIP		U15
99	IC, QUAD OR GATE, 74LS32	074-74LS-032	1	DIP		U4
100	IC, D FLIP-FLOP, 74LS74	074-74LS-074	1	DIP		U17
101	IC, QUAD NAND GATE, 74LS00	074-74LS-000	2	DIP		U5,7
102	IC, D/A CONV, NE5018	053-5018-000	2	AW		U22,23
102	IC, D/A CONV, NE5018	053-5018-000	2	LG		U21,24
103	IC, 8-INPUT NAND, 74LS30	074-74LS-030	1	DIP		U6
104	IC, 3-INPUT NAND, 74LS10	074-74LS-010	1	DIP		U8
105	IC, HEX INVERTER, 74LS04	074-74LS-004	1	DIP		U18
106	IC, 4-16 DECODER, 74LS154	074-74LS-154	1	LG		U14
107	IC, BUFFER, 74LS541	074-74LS-541	4	DIP		U2,3,11,12
108	IC, LEVEL SHIFTER, MC14504B	004-4504-000	1	DIP		U25
109	IC, ANALOG SWITCH, DG508	051-0508-000	1	DIP		U19
110	IC, QUAD OP AMP	060-4741-500	2	DIP		U26,27
111	IC, HEX INVERTER, 74PC04	080-74PC-004	1	DIP		U13
112	IC, QUAD 2 INPUT AND, 74LS08	074-74LS-008	1	DIP		U9
113	IC, PIO, Z8420	070-8420-000	1	LG		U16
114	IC, BUS TRANS, 74LS645	074-74LS-645	1	DIP		U10
115	IC, D FLIP-FLOP, 74LS175	074-74LS-175	1	DIP		U20
116	RESISTOR, 4.7KΩ, 1/4W, 5%	303-0472-000	1	LG	5 BEND	R16
117	RESISTOR, 1MΩ, 1/4W, 5%	303-0105-000	1	LG	5 BEND	R66
118	DIODE, 1N4148	105-4148-000	2	BW	5 BEND	D21,22 ⚠JL
119	TUBING, SHRINK CLR FIT 221, 1/4"	715-2210-140	.375"	AW		⚠JM

SIGNATURES	DATE
DRAWN WHALEN	9-13-90
CHECKED A. YARZEBINSKI	9-25-90
ENGR. T. BRAUNSTEIN	9-26-90
PROJ. MGR. YARZEBINSKI	3-18-92

SEE SHT. 1 FOR REV. LEVEL

MEDRAD INC.
271 KAPPA DRIVE
PITTSBURGH, PA 15238

TITLE
MARK V INJECTOR SERVO CONTROL CARD ASSEMBLY

OWG. NUMBER 78101-10-AP-03-1 REV. JM

DATE COPIED

SHEET 3 OF 3

9 PPI Card

There are two versions of the PPI Card, identified by the card revision level and serial number. Use the chart below to identify card type, then refer to the appropriate description on the following pages.

Revision	Serial Number	PPI Card Type
Revision B	20000 - 25665	Type B
Revision C and above	25665 and Above	Type C

PPI Card Type B

(Serial numbers 20000 to 25665)
For a block diagram of PPI Card type B, refer to page 9 - 3.

Bus Buffers

The control bus is buffered by U3, and the address bus is buffered by U1 and U2. The bidirectional data bus is buffered by U4 and U5, with direction defined by one of the lines on the control bus. These data buffers are enabled by the decoder. The data bus for the primary memory chip is controlled by U5; the backup memory chip data bus is controlled by U4.

Decoder

Decoder U6 provides the enable lines for the data bus buffers, the memory chips, and the RS-232C circuit.

PPI Memory

Primary PPI memory is provided by 8K RAM chip U9. Backup PPI memory is provided by U8. The chips are enabled by signals from the decoder, while outputs are enabled by lines from the control bus.

Memory Comparator

The data buses from the primary and backup memory are continuously compared by U7. If the values do not agree, latch U11 sends a signal (MEMERRINT), enabling the CTC on the I/O Card, to interrupt the processor.

Analog Switches

The enable lines for the memory chips are switched through U16. When power is applied, the switches are closed, connecting the enable lines. When power is removed or low, the switches are open, disabling the enable lines to preserve power.

Power-Down and Battery Circuit

When power is removed, or is low, Q1- Q3 disables U16 and opens the analog switches to disable the memory chips to conserve power as they switch over to battery power. The battery provides backup power for the memory chips to preserve the contents when power is removed.

RS-232C Circuit

This circuit consists of Universal Asynchronous Receiver/Transmitter (UART) U13, baud rate clock U12, line receiver U15, and line driver U14. With this circuit, the Main Unit can communicate with the Remote Panel using an RS-232C serial interface.

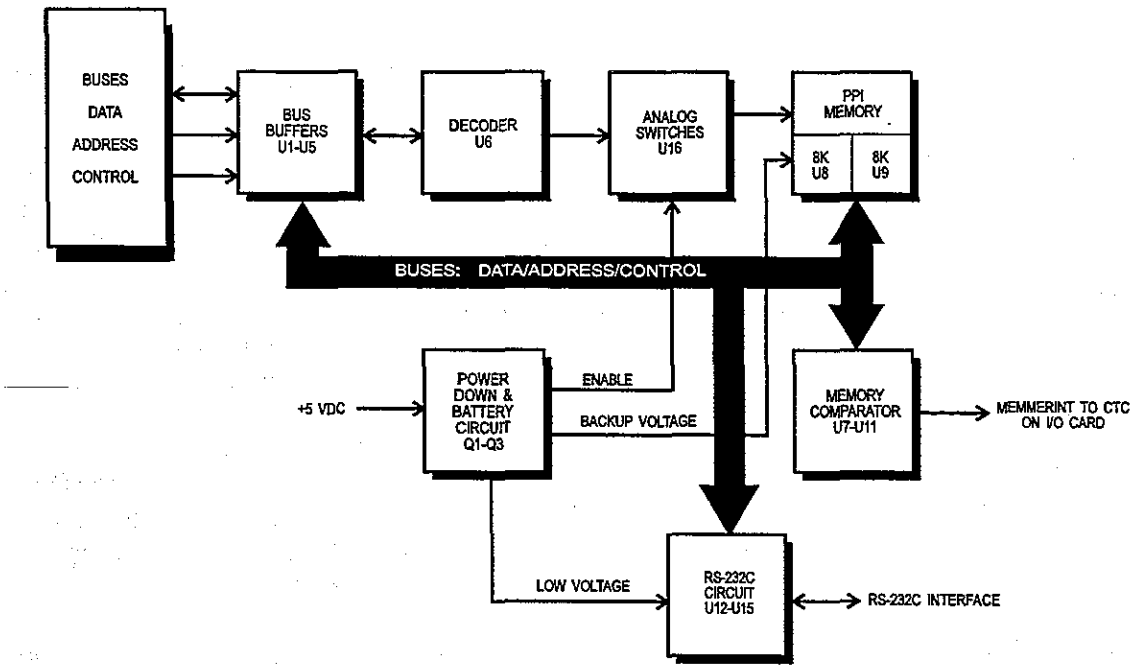


Figure 9.1: Block Diagram: PPI Card Type B

PPI Card Type C

(Serial number 25665 and above)
For a block diagram of PPI Card type C, refer to page 9 - 5.

Bus Buffers

The control bus is buffered by U3, and the address bus is buffered by U1 and U2. The bidirectional data bus is buffered by U4 and U5, with direction defined by one of the lines on the control bus. These data buffers are enabled by the decoder. The data bus for the primary memory chip is controlled by U5; the backup memory chip data bus is controlled by U4.

Decoder

Decoder U6 provides the enable lines for the data bus buffers, the memory chips, and the RS-232C circuit.

PPI Memory

Primary PPI memory is provided by 8K RAM chip U9. Backup PPI memory is provided by U8. The chips are enabled by signals from the decoder, while outputs are enabled by lines from the control bus.

Memory Comparator

The data buses from the primary and backup memory are continuously compared by U7. If the values do not agree, latch U11 sends a signal (MEMERRINT), enabling the CTC on the I/O Card, to interrupt the processor.

Analog Switches

The enable lines for the memory chips are switched through U16. When power is applied, the switches are closed, connecting the enable lines. When power is removed or low, the switches are open, disabling the enable lines to preserve power.

Power-Down and Battery Circuit

When power is removed, or is low, Q1-Q3 disables U16 and opens the analog switches to disable the memory chips to conserve power as they switch over to battery power. The battery provides backup power for the memory chips to preserve the contents when power is removed.

RS-232C Circuit

This circuit consists of Universal Asynchronous Receiver/Transmitter (UART) U13, baud rate clock U12, U19 RS-232 line driver and receiver, and ferrite beads FB1-FB5 added for reduction of conducted noise. With this circuit, the Main Unit can communicate with the Remote Panel using an RS-232C serial interface.

Ferrite Beads

FB1-FB5 are used to suppress noise from the power source.

NOTE: Clearing of PPI Memory: Type C PPI Cards contain a new feature for the simplification of clearing PPI memory. This can be accomplished by removing power, then shorting pin 2 to pin 1 or 3 of JU1. The shorted state should be maintained for several seconds to ensure complete and proper clearing.

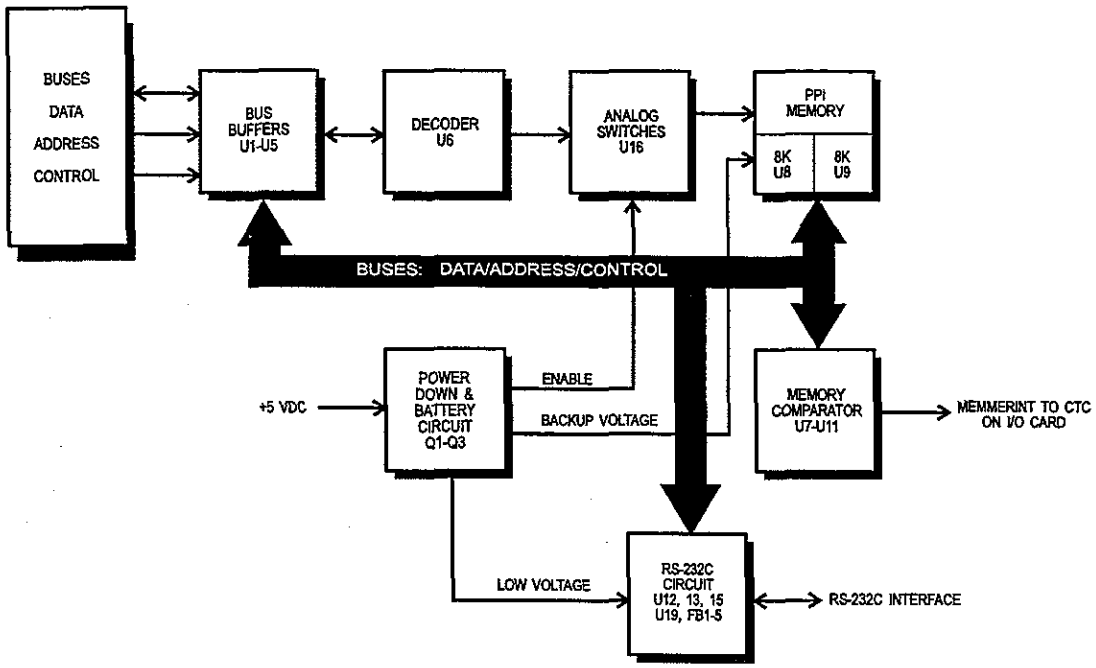
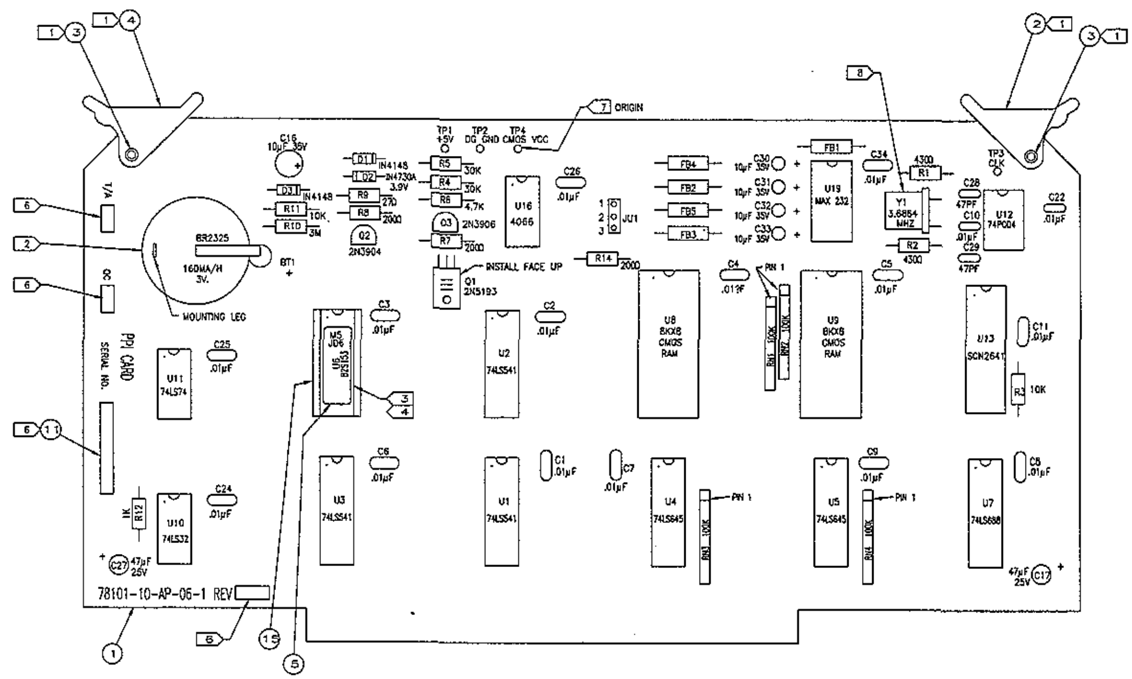


Figure 9.2: Block Diagram: PPI Card Type C

NOTES:

REVISIONS				
REV	ECO NO./EC NO.	DESCRIPTION	DR BY/DATE	APPVD.
S	EC-2490	CAD REGEN. SEE REV. R FOR PRIOR REV. SWITCHED R1 AND R2	PJC 1-13-97	GLK 1-14-97
T	EC-2719	REVISED NOTES	SWB 6-16-97	



8. USE ADHESIVE TO FASTEN Y1 TO THE BOARD. USE RTV OR EQUIVALENT REMOVABLE SILICONE BASED ADHESIVE.

7. LIGHT GUIDED INSERTION ORIGIN LOCATION IS TP4.

6. PRODUCTION TO COMPLETE SERIAL NO. & REV. BLOCKS USING PREPRINTED LABEL (ITEM 11) OR PERMANENT INK. T/A & Q.C. SHOULD INITIAL RESPECTIVE BLOCKS AFTER T/A TEST & Q.C. INSPECTIONS.

5.

PROCESS COMPATABILITY CHART		
ITEM/ DESIG.	DO NOT WAVE SOLDER	DO NOT WATER WASH
6	X	X
2	X	
3	X	
4	X	

ALL COMPONENTS MARKED 'DO NOT WAVE SOLDER' TO HAVE THEIR LOCATIONS MASKED PRIOR TO WAVE SOLDER AND BE INSTALLED AFTER WAVE SOLDER. ALL SOCKETED COMPONENTS TO BE INSTALLED AFTER WAVE SOLDER.

4. (Δ)

3. U6 MUST BE PROGRAMMED PRIOR TO INSTALLATION REF. DOC. #94064-00-PX-01 FOR PROGRAMMING INSTRUCTIONS. UNPROGRAMMED PT. NO. IS 071-8215-300. PAL LABELS ARE TO BE ATTACHED AFTER PROGRAMMING.

2. BATTERY (BT1) NOT TO BE INSTALLED UNTIL ALL ELECTRICAL CHECK-OUT PROCEDURES FOR THIS CARD ASS'Y. HAVE BEEN COMPLETED. BATTERY IS *NOT TO BE HANDLED WITH METAL OBJECTS AND IS TO BE STORED IN* A MANNER TO PREVENT BATTERY CASES FROM TOUCHING EACH OTHER, SO AS TO GUARD AGAINST ACCIDENTAL DISCHARGE.
DO NOT WAVE SOLDER BATTERY. HAND SOLDER 5 SECONDS MAX.

1. INSTALL ITEMS 2, 3 & 4 AFTER WAVE SOLDERING.

NOTES:

SIGNATURES		DATE
DRAWN	LANE	7-8-85
CHECKED	YARZEBINSKI	10-29-85
ENGR.	STULEN	10-30-85
PROD.	N/A	

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES

MEDRAD® INC.
ONE MEDRAD DRIVE
INDIANOLA, PA 15051-0780

TITLE: MK V INJECTOR – PPI CARD ASSEMBLY

SIZE: D | DWG. NUMBER: 78101-10-AP-06-1 | REV. T
SCALE: NTS | DATE COPIED: | SHEET 1 OF 2

BILL OF MATERIAL

ITEM	DESCRIPTION	PART NUMBER	QTY.	PROCESS CODE	PREP CODE	REF. DESIG
1	PC CARD, (REV E AND UP)	78107-10-PC-06	1	LG		
2	CARD EJECTOR (WHITE)	510-7000-000	1	AW		
3	CARD EJECTOR PIN	510-7001-000	2	AW		
4	CARD EJECTOR, (YELLOW)	510-7002-000	1	AW		
5	LABEL, BLANK PAL	550-0017-619	1	AW	NOTE C	U6
6	BATTERY, BR2325-1HB	497-2325-100	1	AW		BT1
10	PIN HEADER, 3 POSITION	518-8001-003	1	BW		JU1
11	LABEL, BLANK SERIAL NUMBER	550-0093-652	1	BW		
12	TUBULAR TERMINAL	642-1238-000	4	BW		TP1-TP4
15	IC SOCKET, 20 PIN	545-8201-020	1	LG		U6
20	CAP, 10UF, 35V	204-0106-135	5	LG	.1-LS	C16,C30-C33
21	CAP, 47UF, 25V	204-0476-025	2	LG	.1-LS	C17,C27
22	CAP, .01UF, 50V	201-0103-050	16	LG	.1-LS	C1-11,22,24-26,34
23	CAP, CERAMIC, 47PF	201-0470-050	2	LG	.1-LS	C28,C29
25	CRYSTAL, 3.6864 MHZ	180-0037-000	1	LG		Y1
26	FERRITE BEAD	280-1625-000	5	LG	6 BEND	FB1-FB5
30	TRANSISTOR, 2N5193	125-5193-000	1	BW		Q1
31	TRANSISTOR, 2N3904	120-3904-000	1	BW		Q2
32	TRANSISTOR, 2N3906	121-3906-000	1	BW		Q3
35	DIODE, 1N4148	105-4148-000	2	AXI		D1,D3
36	DIODE, 1N4730A, 3.9V	102-4730-050	1	LG	5 BEND	D2
40	RESISTOR, 10 KOHM, 1/4 W 5%	303-0103-000	2	AXI		R3,R11
41	RESISTOR, 430 OHM, 1/4 W 5%	303-0431-000	2	AXI		R1,R2
42	RESISTOR, 30 KOHM, 1/4 W 5%	303-0303-000	2	AXI		R4,R5
43	RESISTOR, 4.7 KOHM, 1/4 W 5%	303-0472-000	1	AXI		R6
44	RESISTOR, 200 OHM, 1/4 W 5%	303-0201-000	3	AXI		R7,R8,R14
45	RESISTOR, 27 OHM, 1/4 W 5%	303-0270-000	1	AXI		R9
46	RESISTOR, 3 MOHM, 1/4 W 5%	303-0305-000	1	AXI		R10
47	RESISTOR, 1 KOHM, 1/4 W 5%	303-0102-000	1	AXI		R12
50	RESISTOR ARRAY, 100 KOHM SIP	340-4310-104	4	LG		RN1-RN4
60	IC, D FLIP-FLOP, 74LS74	074-74LS-074	1	DIP		U11
61	IC, QUAD 2-INPUT OR 74LS32	074-74LS-032	1	DIP		U10
62	IC, BUFFER, 74LS541	074-74LS-541	3	DIP		U1,U2,U3
63	IC, QUAD ANALOG SWITCH, 4066	004-4066-000	1	DIP		U16
64	IC, CMOS RAM, TC5564-PL15	071-5564-015	2	LG		U8,U9
65	IC, BUS TRANS, 74LS645	074-74LS-645	2	DIP		U4,U5
66	IC, RS232, MAX232	051-0232-000	1	DIP		U19
67	IC, HEX INVERTER, 74PC04	080-74PC-004	1	DIP		U12
68	IC, UART, SCN2641	051-2641-100	1	LG		U13
69	IC, COMPARATOR, 74LS688	074-74LS-688	1	DIP		U7
70	IC, PAL, BLANK	071-8215-300	1	AW	NOTE C	U6

SIGNATURES		DATE
DRAWN	MAIESE	3/11/91
CHECKED	KISTE	3/12/91
ENGR.	KLODOWSKI	9-28-94
PROJ. MGR.	YARZEBINSKI	9-28-94

SEE SHT. 1 FOR REV. LEVEL

MEDRAD® INC.
ONE MEDRAD DRIVE
INDIANOLA, PA 15051-0780

TITLE
MKV INJECTOR - PPI CARD ASSEMBLY

DWG. NUMBER 78101-10-AP-06-1 REV. T

DATE COPIED

SHEET 2 OF 2

10 Control Panel

The Control panel is comprised of the keyboard overlay attached to the Display Card. Three different types of interchangeable Display Cards have been produced. Refer to page 10 - 2 for a block diagram of the Control Panel cards.

Keyboard Overlay

The keyboard overlay contains snap-action membrane keys, interconnected in a matrix of four columns and eight rows. This matrix is connected to the Display Card, then to the I/O Card, where PIO2 senses key closures for the system.

Display Card

The Display Card contains the alphanumeric displays and LEDs that show through the keyboard overlay. These devices convey messages and operating status to the operator. The Display Card contains the Sentinel display, numeric displays, and LED displays.

Sentinel Display

The Sentinel is made up of eight, 4-character display units (DS1 through DS8), creating a 32-character read-out. These devices receive data and control information from the I/O Card.

Numeric Display Drivers and Numeric Displays

Three display groups are used to display injection parameters on the Control panel. Each display group consists of a display driver (U1, U2, or U4), and numeric display units. Display drivers also receive the data and control line information from the I/O Card. Group designations are as follows:

Display Driver U1, displays Volume (DS23 - DS26), Flow Rate (DS11, DS12), and Rise/Fall (DS9, DS10).

Display Driver U2, displays Pressure [limit] (DS27 - DS30) and Injection Duration (DS13-DS15).

Display Driver U4, displays Program Number (DS16, DS17), Total Levels (DS18), Level (DS22),and Delay (DS19-DS21).

LED Driver, Transistor Driver and LEDs

The remainder of the Display Card circuit controls and drives LEDs used as backlights of various indicators on the Control panel. Display driver U3 controls all LEDs, and receives data and control information from the I/O Card. Each LED group contains drivers such as Q5 and Q6, or IC U5. These three columns of LEDs are enabled by Q20 through Q22, and driven by Display Driver U3.

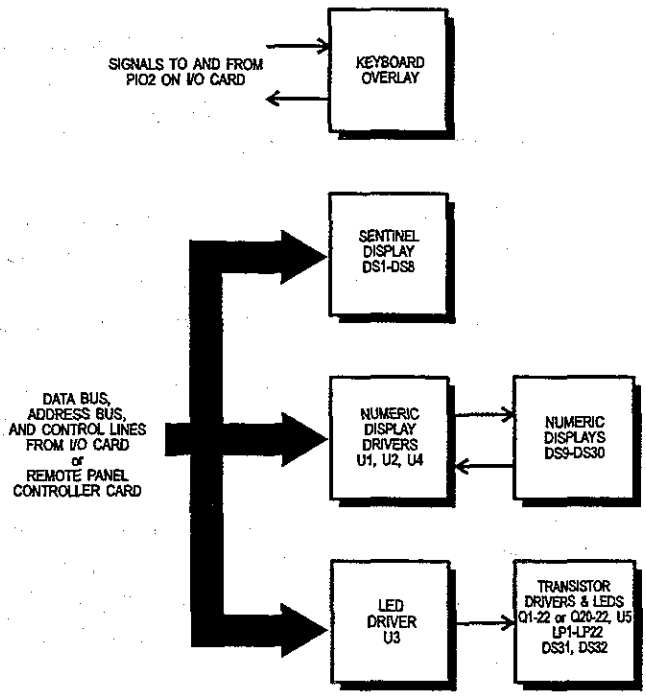
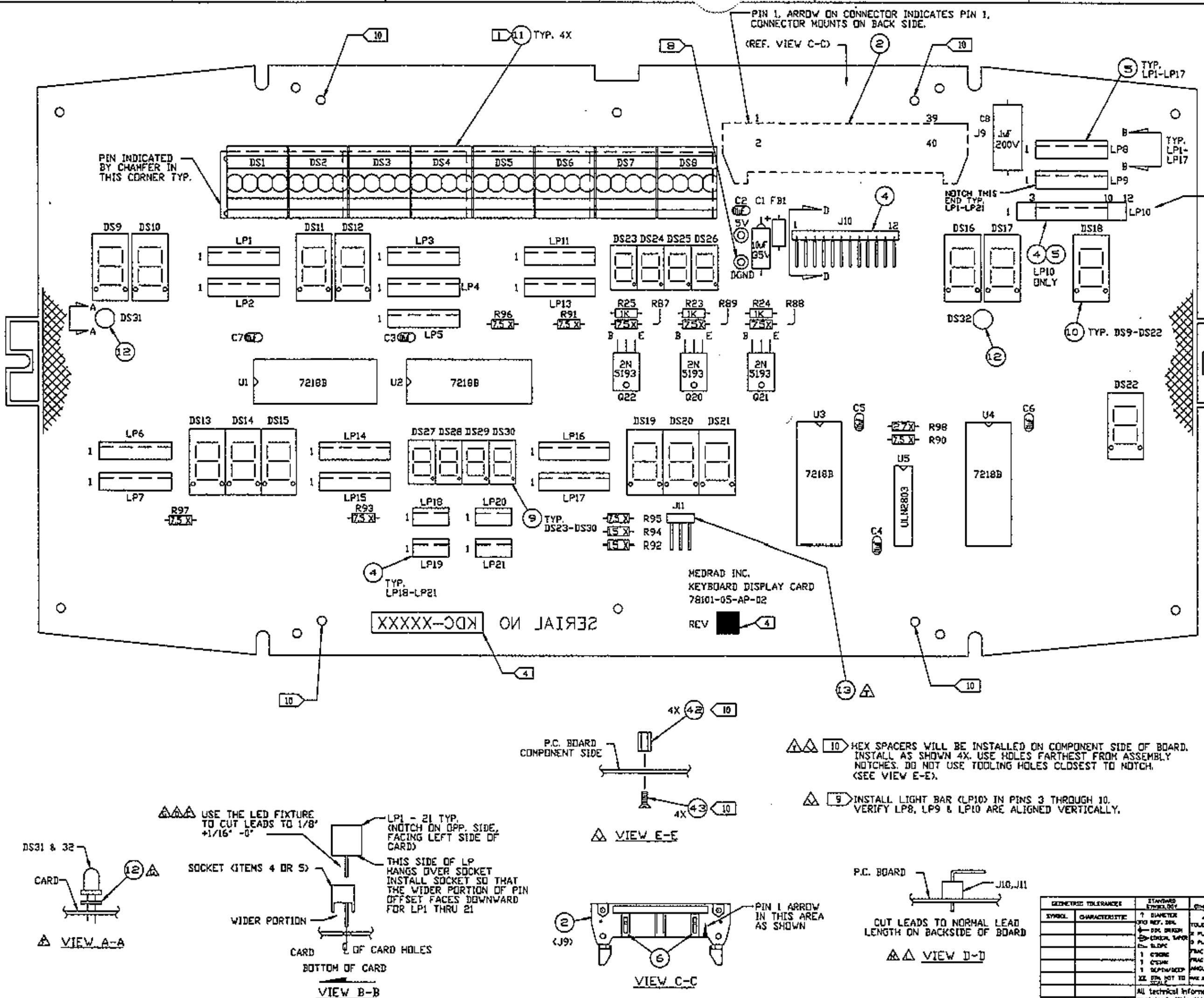


Figure 10.1: Block Diagram: Control Panel



REVISIONS

REV	ECO NO.	DESCRIPTION		DATE	APPVD.
A	DDN-316	REMOVED R63, 65 FROM SHEET 1	IN LINE	4-20-88 JCB	4-21-88 AY
B	DDN-320	ITEM 5 PIN WAS 518-5306-005, ADDED ITEM 10, (ON SH2/2) DELETED ORIG. VIEW VIEW C-C, VIEW C-C WAS D-D	IN LINE	5-3-88 JCB	5-4-88 AY
C	DDN-340	ADDED TRIM LEAD NOTE TO VIEW B-B	IN LINE	6-21-88 JCB	6-21-88 AY
D	DDN-366	CUT LENGTH IN VIEW B-B WAS 3/32"	IN LINE	9-23-88 JCB	9-26-88 AY
E	DDN-437	ADDED NOTE C	IN LINE	3-14-89 JCB	3-14-89 AY
F	DDN-475	CR78101-05-15 VIEW A-A WAS DS25 & 26, WAS 7/16" (437)	IN LINE	6-8-89 JCB	6-8-89 MWR
G	DDN-583	CR78101-05-17, DELETED 2 ITEM 7, REV. DS31/32 LEAD CUTTING, ADDED ITEM 11		1-29-90 JCB	1-31-90 AY
H	DDN-643	CR78101-05-19, ADDED NOTES D & E C1 ON PTS. LIST 20V		5-3-90 JCB	5-4-90 AY
I	DDN-667	CR78101-05-20, REV. FOR USE W/REV. C & UP BOARDS.		6-7-90 JCB	6-11-90 AY
J	DDN-708	CR78101-05-22, ADDED NOTE G EFFECTIVITY S.N. 21766		8-15-90 JCB	8-15-90 AY
K	DDN-750	CR78101-05-23, ITEM 12 WAS 530-0093-652, ADDED ITEM 13		10-18-90 JCB	10-19-90 AY
L	EC-38	ADDED VIEW D-D FOR J10 CONN.		1-10-91 JCB	1-15-91 AY
M	EC-416	REDRAWN FOR PCAS RE-LAYOUT OF CARD		10/7/91 TJM	10/8/91 RJB
N	EC-437	REV.VIEW D-D (SHT.1) ITEM 20 QTY.WAS 3 (SHT.2)		10/21/91 MAW	10-23-91 DPK
P	EC-974	ADDED C8(IT. 23) AND NOTE 7		2-16-92 SCS	2-21-92 DPK
R	EC-1048	PROCESS CODE CHANGES		2-26-93 SCS	DPK
S	EC-1433	REV. NOTE 7, IT. 6 & 22 PROCESS CODE WAS AW		3/21/94 TJM	3-22-94 DPK
T	EC-1567	ADD ITEM 13		7-28-94 SCS	7-29-94 AJY
U	EC-1790	GENERAL REVISIONS		5-5-95 SCS	5-17-95 DPK
V	EC-1807	ADDED NOTES 9 & 10, VIEW E, EFFECTIVITY S/N 25496		5-31-95 PJC	6-2-95 AJY
W	EC-1818	EFFECTIVITY S/N TO BE 25497 NOT 25496 SHOWN ON REV V		EJP 6-9-95	
Y	EC-1884	ITEM 42 WAS SHOWN AS HEX SPCR		EJP 8-17-95	

8\. ORIGIN LOCATION, DGND

7\. FOR REVISION J BOARDS ONLY CUT CROSS HATCHED SHIELDING ON TOPSIDE OF BOARD ON BOTH EARS. USE A DREMEL TOOL OR EQUIVATENT.

6\. DESIG. DELETED: Q1-Q19, R1-R22, R26-R86, LP12

5\. LAST DESIG. USED: FB1, C7, DS32, LP21, Q22, R98, U5

4\. REV. LEVEL BLOCK MUST BE FILLED IN WITH THE REV. LEVEL LETTER OF THE ASS'Y. DWG. TO WHICH THE BOARD WAS BUILT.
THE SERIAL No. BLOCK MUST BE FILLED IN WITH A SCRIBE, PERMANENT MARKER, OR PRE-PRINTED LABEL (ITEM 8).

3\. INSTALL ALL SOCKETED PARTS AND PARTS MARKED 'DO NOT WAVE SOLDER' AFTER SOLDER MASK ALL COMPONENT LOCATIONS FOR THESE PARTS PRIOR TO WAVE SOLDER. ALL COMPONENTS MARKED 'DO NOT WAVE SOLDER' TO BE INSTALLED AFTER WAVE SOLDER.

2\.

PROCESS COMPATABILITY CHART		
ITEM/DESIG.	DO NOT WAVE SOLDER	DO NOT WATER WASH
2	X	
6	X	
30	X	
42,43	X	

10\. HEX SPACERS WILL BE INSTALLED ON COMPONENT SIDE OF BOARD. INSTALL AS SHOWN 4X. USE HOLES FARTHEST FROM ASSEMBLY NOTCHES. DO NOT USE TOOLING HOLES CLOSEST TO NOTCH. (SEE VIEW E-E).

9\. INSTALL LIGHT BAR (LP10) IN PINS 3 THROUGH 10. VERIFY LP8, LP9 & LP10 ARE ALIGNED VERTICALLY.

1\. NOTE THAT FOUR (4) 28 PIN SOCKETS (ITEM 7) ARE USED TO INSTALL DS1-DS8. WHEN INSTALLING DS1-DS8, INSTALL DS8 FIRST. THEN PROCEED TO DS7, 6, 5, 4, 3, 2 & FINALLY DS1. NOTE ALSO, THAT THE EXTREME LEFT SIDE PIN HOLES OF ALL FOUR SOCKETS WILL NOT BE USED AND THAT THE LEFT END SOCKET WILL PROTRUDE BEYOND DS1.

SIGNATURES		DATE
DRAWN	BUTLER	8-10-87
CHECKED	YARZEBINSKI	8-11-87
ENGR.	STULEN	8-11-87
	N/A	

DO NOT SCALE DRAWING

MEDRAD INC.
271 KAPPA DRIVE
PITTSBURGH, PA 15238

TITLE: MKV INJECTOR - KEYBOARD DISPLAY CARD ASS'Y

SIZE D | DWG NUMBER 78101-05-AP-02 | REV Y

SCALE NTS | SHEET 1 OF 2

BILL OF MATERIAL

ITEM	DESCRIPTION	PART NUMBER	QTY.	REF. DESIG.	PROCESS CODE	PREP. CODE
1	PC CARD, (REV. G AND UP)	78101-05-PC-02	1		LG	
2	CONNECTOR, 40 PIN HEADER	518-0208-040	1	J9	AW	
3	CONNECTOR, 12 PIN HEADER	518-0528-012	1	J10	BW	
4	SOCKET, SIP, 4 PIN	518-5837-004	5 △	LP10,18,19,20,21	LG	
5	SOCKET, SIP, 8 PIN	518-5306-008	16	LP1-LP11,LP13-LP17	LG	
6	PIN, POLARIZING KEY	518-3518-000	2	J9 △S	AW	
7	TUBULAR TERMINAL	642-1238-000	2	DG, +5V	BW	
8	LABEL, BLANK SERIAL NUMBER	550-0093-652	1		AW	NOTE
9	SOCKET, 10 PIN 0.2" DIP	545-0210-010	8	DS23-DS30	LG	
10	SOCKET, 10 PIN 0.3" DIP	545-0310-010	14	DS9-DS22	LG	
11	SOCKET, 28 PIN DIP	545-8281-028	4	DS1-DS8	LG	
12	SPACER, T 1-1/4	600-0104-020	2	DS31-DS32	BW	
13	CONNECTOR, 3 PIN HEADER	518-0528-003	1	J11 △T	BW	
14						
15	TRANSISTOR, 2N5193	125-5193-000	3	Q20,Q21,Q22	BW	
16						
17	FERRITE BEAD	280-1625-000	1	FB1	LG	5-BEND
18						
19						
△N 20	CAP, .01uF, 50V	201-0103-050	6	C2-C7	LG	.1-LS
21	CAP, 10uF, 35V	204-0106-035	1	C1	LG	8-BEND
22	CAP, .1?f, 200V	210-0104-220	1	C8 △S △P	BW	
23						
24						
25	RESISTOR, 75 X 1/4W, 5%	303-0750-000	3	R87-R89	AXI	
26	RESISTOR, 1K X1/4W, 5%	303-0102-000	3	R23-R25	AXI	
27	RESISTOR, 7.5 ,X1/4W, 5%	303-1075-000	6	R90,91,93,95,96,97	AXI	
28	RESISTOR, 15 X1/4W, 5%	303-0150-000	2	R92,R94	AXI	
29	RESISTOR, 27 X 1/4W, 5%	303-0270-000	1	R98	AXI	
30	DISPLAY, LED, RED, DL1414	485-1414-000	8	DS1-DS8	AW	
31	DISPLAY, 7-SEG LED, RED, .43"	485-5082-000	14	DS9-DS22	AW	
32	DISPLAY, 7-SEG LED, RED, .3"	485-7503-000	8	DS23-DS30	AW	
33	LED, RED, T1-1/4	441-9247-000	2	DS31-DS32	BW	
34	LED, LIGHT BAR, RED, 8 PIN	485-2350-000	16	LP1-LP11,LP13-LP17	AW	
35	LED, LIGHT BAR, RED, 4 PIN	485-2300-000	4	LP18-LP21	AW	
36						

ITEM	DESCRIPTION	PART NUMBER	QTY.	REF. DESIG.	PROCESS CODE	PREP. CODE
37						
38						
39						
40	IC, LED DRIVER, 7218-B	072-7218-000	4	U1-U4	LG	
41	IC, DRIVER, 8 CHAN ULN2803	119-2803-000	1	U5	LG	
42	SPACER, 4-40 x 1/4 O.D. x 3/8 LG.	625-8322-441	4	△		
43	SCREW, 4-40 x 1/4 FHM	603-0440-140	4	△		

SIGNATURES		DATE
DRAWN	BUTLER	8-10-87
CHECKED	YARZEBINSKI	8-11-87
ENGR.	STULEN	8-11-87
PROJ. MGR.	N/A	

SEE SHT. 1 FOR REV. LEVEL

MEDRAD INC.
271 KAPPA DRIVE
PITTSBURGH, PA 15238

TITLE
MKV INJECTOR - KEYBOARD DISPLAY CARD ASS'Y

DWG. NUMBER 78101-05-AP-02 REV. Y

DATE COPIED

SHEET 2 OF 2

11 Power Drive Circuit

The Power Drive Circuit supplies, and controls power to the Injector Head Plunger Motor.

The Power Drive Circuit is located primarily on the Power Drive Card. The Safe relay, Reverse relay, and selected output stage components are located elsewhere in the unit. The filter choke is mounted on the chassis frame.

The information in this section describes three versions of the Power Drive Card. Cards designated "PDC" are those with serial numbers below 60000, those designated "PDCP" are serial number PDCP 60000 and above, and those designated "PDCI" are cards serial number PDCI 70000 and above. The following information describes the PDC Card, while a circuit description for the PDCP Card can be found on Page 11 - 9, and for the PDCI Card on Page 11 - 17.

NOTE: The PDC Card cannot be used in Mark V *Plus* systems.

NOTE: The Power Drive Card International (PDCI) was redesigned to ensure compliance with IEC 601-1 electrical standards, regarded as the worldwide electrical standard. A new power amplifier design coincides with the release of the MKV *Plus* International Injection System. The new International boards are identified by having an "I" after the designated prefix (PDCI), and are not interchangeable with any predecessor.

PDC

(Serial numbers below 60000)
Refer to pages 11 - 7 and 11 - 8 for block diagrams of the PDC Card.

Brake Circuit Q8, Q9, Q10

The Brake Circuit is used to stop the plunger motor at the end of an injection, or if an error condition occurs during an injection. This process is called Dynamic Braking. When the Safe Relay opens, the motor will continue to turn, thereby acting as a generator producing voltage. When the brake is activated, the motor winding is connected across two .75 ohm, 5 watt resistors, or one .68 ohm 2 watt resistor, stopping the motor. At the end of an injection, the error signal (ERRSIG, a command from the Servo Control Card) goes negative (-1V), activating the Brake Sensing Circuit Q8 - Q10. A SYSTEM OVERRIDE, AUX MONITOR, or overrate signal can also activate the brake.

Overcurrent Shutdown Circuit U4B, DRC Q1 (Q11 on CPA)

The overcurrent shutdown circuit (U4B-C on PDC and Q1 on DRC [Q11 on CPA]) opens the motor voltage path if excessive current is flowing through the plunger motor circuit. The Sampling Resistor is in series with the motor, and voltage across it is directly proportional to current through the motor. This voltage is an input to Motor Current Amplifier U4C, and to one input of the Overcurrent Shutdown comparator (U4B). The other input of U4B is tied to a voltage divider, to establish an overcurrent shutdown reference (approximately -6V). When the output of U4C rises above this reference voltage, the output of U4B reaches negative saturation. This voltage is applied to the Gate of Overcurrent Shutdown FET Q1 on the DRC (Q11 on CPA), forcing it into cut-off and opening the motor voltage path.

Safe Relay / Safe Relay Enable K1, Q5

Safe Relay K1 completes the motor voltage path between the SCR Bridge stage, and the Plunger Motor. K1 also provides an additional pair of normally-closed contacts to allow the Mechanical Stop Motor to run while the injector is disarmed, yet prevent the Plunger motor from running. K1 is enabled by a Forward or Reverse load command from the injector head, or when the injector is armed (Safe Relay Enable [SAFRELEN] from the SCC). In both cases, theses signals cause Q5 to conduct, providing a ground path to energize K1 (SAFRELO). This action disables the Mechanical Stop Motor by breaking connections to the motor, and allowing power to flow to the Plunger motor. The Safe Relay is disabled by a SYSTEM OVERRIDE/AUX MONITOR from the PDC, or a loss of the SAFRELEN from the SCC.

Reverse Relay Enable Circuits K2

When Reverse loading, both Safe Relay K1 and Reverse Relay K2, must be energized. When REVERSE load is activated, +26 volts energizes K2, reversing the polarity of the plunger motor.

System Override

The SYSTEM OVERRIDE shuts down the PDCP if the system detects the presence of a "System Monitor' type condition (Overpressure, Overvolume, or Overrate [via Aux Monitor]). When the SYSTEM OVERRIDE signal from U16 (PIO 3) on the SCC goes high, the signal is sent through D21 to: Disable the Safe Relay (R50, R82, Q4), activate the brake (D28, D25, Q10), and disable pulses to SCR bridge controller (D28, R87, Q3). SYSTEM OVERRIDE and AUX MONITOR are ORed on the PDC to form a redundant shut-down circuit.

Differential Amplifier U1B

The Differential Amplifier (U1B) is used to establish a reference sine wave for use by the zero crossing detector. Inputs to U1B are positive half-waves taken from the secondary of Transformer T1, and half-waves rectified by diodes in the SCR bridge Z1. The positive half-waves coincide with both the positive and negative halves of the input sine-wave. When the non-inverting input of U1B (pin 5) goes positive, the inverting input of U1B (pin 6) will be at or near zero volts. Output of U1B will go positive, producing the positive half of the sine-wave. Likewise, when U1B pin 6 begins to go positive, the voltage at U1B pin 5 will be at or near zero volts. The output of U1B will go negative, producing the negative half of the sine-wave. This action reestablishes the reference sine-wave.

Phase Shift Network U1A

The Phase Shift Network is used to produce a sine-wave that is phase shifted 0.4 mS ahead of the incoming sine-wave. This ensures that sufficient voltage and current exist to fire the SCR bridge. Input to the Phase Shift Amplifier, U1A, is the output of U1B. R6 adjusts the amount of phase shift at the output of U1A.

Zero Crossing Detector U1C, U1D

The Zero Crossing Detector circuit will produce a positive going pulse (-15v to 0), and reset the Ramp Generator circuit (U2A) when the input sine-wave passes through zero. Input to this stage is the phase shifted sine-wave from U1A. U1C and U1D function as a "Window Detector", each producing a positive output when input voltage is within the established window. The non-inverting input to U1C has a positive offset voltage, while the output of U1C goes to positive saturation when the inverting input voltage drops below the offset. The inverting input of U1D also has a negative offset. Output of U1D will go to negative saturation when voltage at the non-inverting input drops below the offset. The outputs of U1C and U1D are ANDed by D3-D4, and when both are positive, a positive going pulse is sent to reset the Ramp Generator circuit.

Ramp Generator Q1, U2A

Integrator U2A generates 2 volt (-2 to 0 volt) ramp waveforms between each zero crossing. These ramps are used to establish a reference for the Trigger Comparator (U2D). During an injection, the Error signal is summed with the ramps and applied to U2D. The Error signal raises the DC reference level of the ramps. The integrator is reset (zero crossing detector applies a positive going pulse to the gate of Q1) when the sine-wave passes through zero.

Trigger Comparator, SCR Controller U2D

The Trigger Comparator (U2D) determines duration of pulses that fire the SCR bridge. The input to U2D is the summed Error signal and ramp wave-form. Duration of pulses is determined by the amount of time that the input wave-form value is greater than zero volts. In standby, input to U2D is 0 volts. The output of U2D is negative saturation. Diode D18 supplies a ground path for +15 volts across R38, sending Q2 into cut-off.

During an injection, the Error signal raises the ramp wave-form above zero volts. When ramp voltage is above zero, output of U2D switches to positive saturation, reverse biasing D18, and removing the ground path for the +15 volts. This voltage is applied to Q2 (through R38, D19 and D20), providing a ground path for +26 volts (through R12, R13, and Q2), which creates a positive to negative transition on the primary of pulse transformer T1. The pulse transformer will invert the polarity of the secondary, creating a negative to positive pulse to fire the SCR bridge. The duration of the pulse is determined by the amount of that time the input to U2D is above zero volts.

Transistor Q3 is used to ground trigger pulses (remove base voltage to Q2) if a SYSTEM OVERRIDE, AUX MONITOR, or overrate injection occurs.

Full Error Trigger U2C

The Full Error Trigger will fire the SCR bridge if a large, instantaneous Error signal does not allow U2D to trigger the SCR bridge. In order for the Trigger Comparator (U2D) and the SCR Controller to fire the SCR bridge, the output to U2D must be allowed to drop below zero. If the Error signal is too large, input of U2D stays above zero, consequently output is held in positive saturation. If this occurs, U2C will invert the output of the zero crossing detector, and pulse the SCR Controller. The pulses will continue until the Error signal drops to a value which allows output of U2D to pulse normally, and resume firing of the SCR bridge.

Delinearizing Network

The circuit comprised of R80, R22-27, D7-8, and C16, increases drive circuitry sensitivity to small error signals, and decreases sensitivity to larger error signals.

Power Output Stage

AC power from the power transformer is applied to the SCR bridge Z1. The output of the bridge, controlled by gate pulses from the SCR controller, is filtered by L1 and C1 on the DRC, or L1 and C13 on the CPA. The SCR bridge is protected by an MOV across the AC input. The SCR Bridge output is protected by MOV Z2, while direction of motor rotation is controlled by Reverse Relay K2. Motor current is sampled for the pressure circuits and the overcurrent shutdown circuit by Sampling Resistor R4 on the DRC (R57 in the CPA).

Elliptical Filter U4D

The circuit surrounding U4D removes the fundamental ripple frequency and harmonic noise from the motor current signal. Output is sent to the Pressure Amplifier.

Pressure Amplifier U4A

The filtered motor current signal is amplified by U4A. Output is the actual pressure signal PRESSIG, sent to the multiplexer and pressure limit circuitry on the SCC Card. This signal is also used by the Loading Pressure Limit Circuit on the same card.

Loading Pressure Limit Control - Q6

During loading, if pressure exceeds 200 PSI, Q6 conducts to limit loading rate and pressure.

Motor Current Amplifier U4C

U4C circuitry amplifies and inverts the motor current signal from sampling resistor R57, in series with the motor. Output of the current amplifier is proportional to motor current. This signal is used by Velocity Amplifier U3B, Auxiliary Monitor U3A, and Overcurrent Shutdown Circuit U4B.

Velocity Amplifier U3B

The inputs to velocity amplifier U3B are motor voltage, and the current signal from the current amplifier; these two signals are opposite in polarity and added to obtain the output of U3B, an analog derivative of actual velocity.

Overrate Detector U3C

By comparing the actual velocity signal to the FLOW SELECTED input, U3C detects when the velocity exceeds the flow command. When this occurs, the output of U3C nullifies the input to U2D, stopping the trigger pulses to the SCR bridge. The output of U3C is sent to U3D, activating the brake, and causing Q3 to conduct (shorting SCR Trigger pulses to ground).

Brake Comparator U3D

If the velocity exceeds the flow command, U3D activates brake Q10, activates Q3 to cease firing of the SCRs, and triggers auxiliary monitor U3A.

Auxiliary Monitor U3A

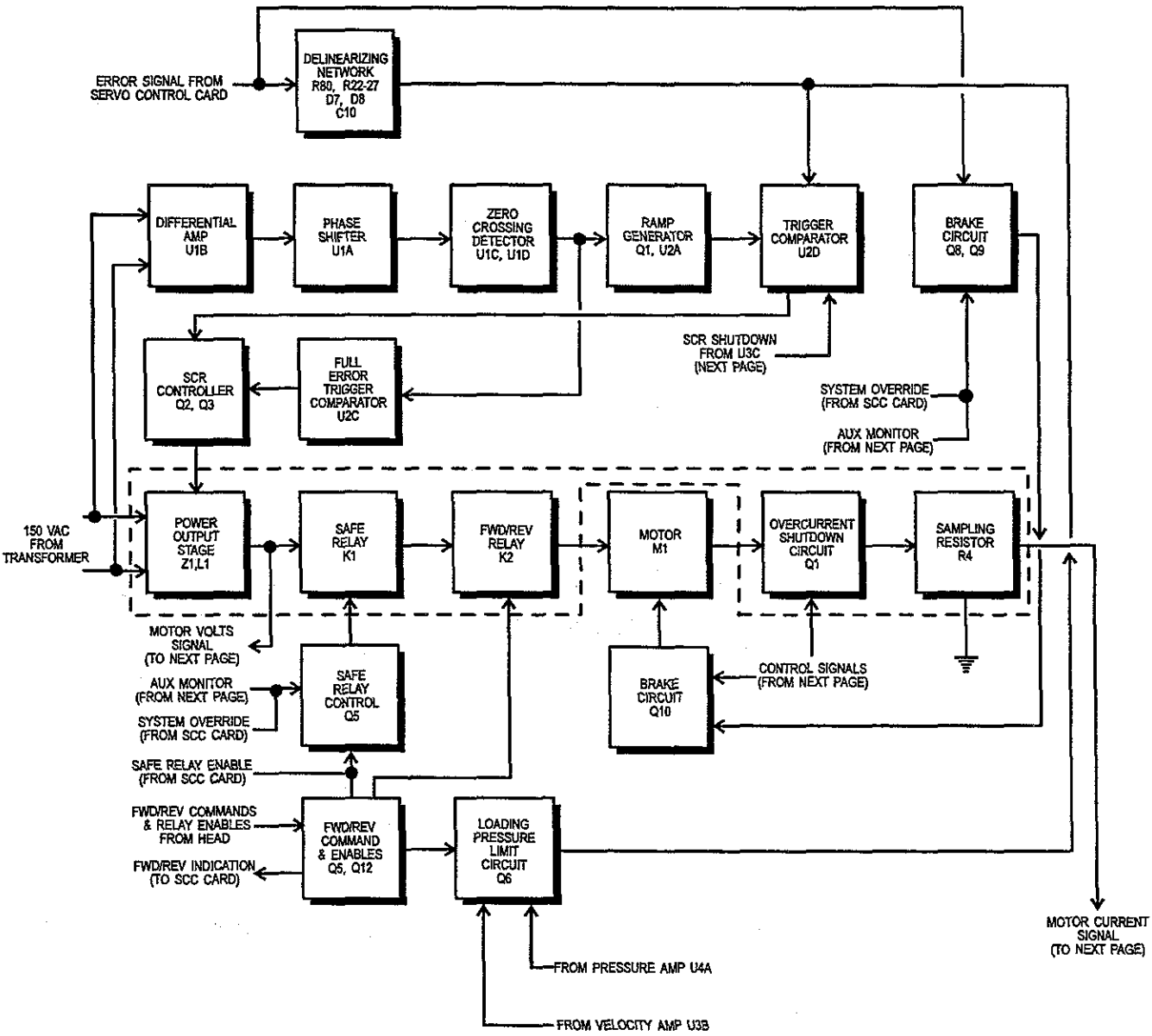
The AUX MONITOR indication is given if the output of Motor Current Amplifier U4C is excessive or if Velocity Comparator U3C indicates that the speed of the motor is greater than the selected flow rate command. When either of these conditions occur, Aux Monitor circuit U3A sends a signal to three other circuits on the PDC. The AUX MONITOR signal: Causes Q3 to conduct, thereby stopping the firing of the SCR bridge; Causes Q4 to conduct, grounding the Safe Relay Enable (SAFRELEN), thereby disabling the Safe Relay; Activates the Brake FET, to stop the plunger motor. The AUX MONITOR signal is also sent to U16 (PIO 3) on the SCC to interrupt the CPU and terminate the injection.

Forward/Reverse Loading Circuit U2A, R28

The Forward/Reverse Loading circuit applies a fixed load profile voltage which is summed with the output of Ramp Generator U2A, to trigger the SCR bridge and produce a drive voltage for the plunger motor. Slow acceleration during loading is provided by the charging action of capacitor C9 and R30. Loading pressure and velocity limiting are controlled through Q6.

Forward/Reverse Loading:
When the Forward load button on the injector head is pressed, +26 volts is sent through voltage divider (R28, R29, R31, R42) to be summed with the output of Ramp Generator U2A. If Reverse load is pressed, the action is similar with these exceptions: Pressing Reverse load also energizes Reverse Relay K2 to reverse the motor lead polarity; +26 volts also passes through blocking diode D10 (prevents Forward load from energizing K2).

Forward/Reverse Indication - Q12:
The Forward/Reverse Indication (FWD/REV IND) alerts the system that either FORWARD or REVERSE load has been pressed. When either button is pressed on the injector head, Q12 conducts sending an active low FWD/REV IND to U16 (PIO 3) on the SCC, prompting the system to withdraw the SAFRELEN.



* *NOTE: Blocks that appear within the dotted lines are not located on the PDC.*

Figure 11.1: Block Diagram: Power Drive Card (PDC) and Associated Circuitry (sheet 1 of 2)

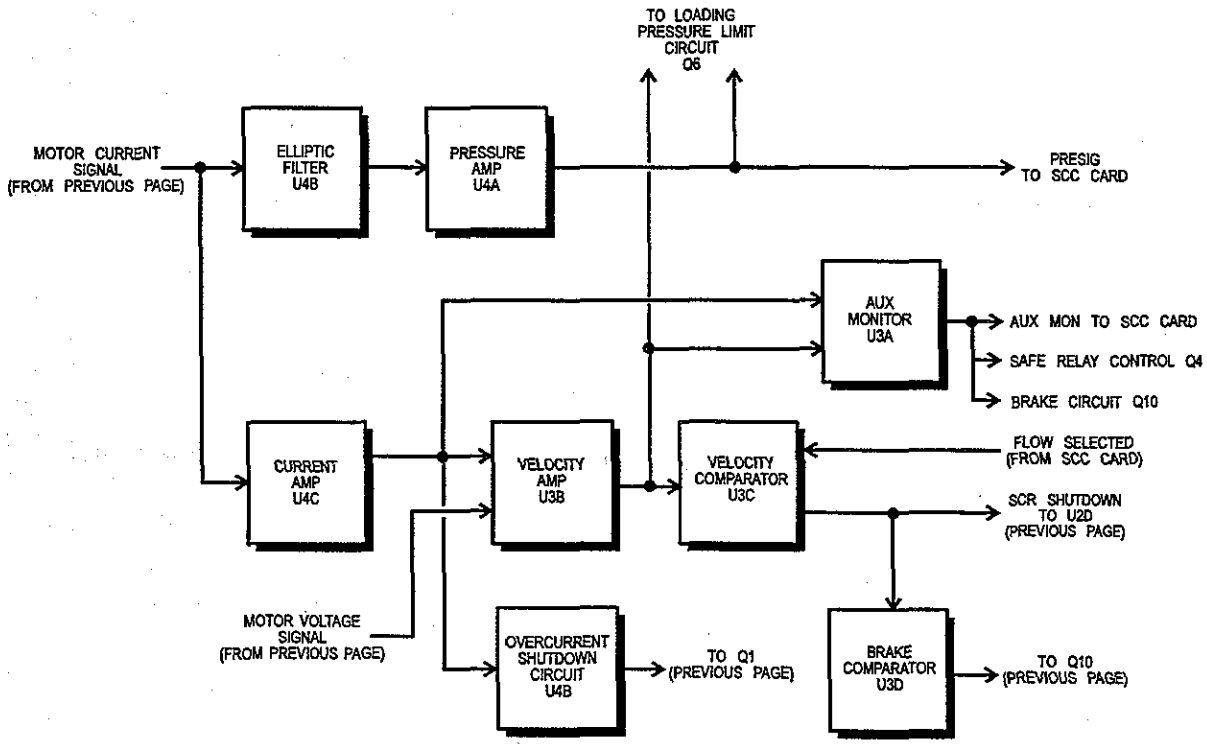


Figure 11.2: Block Diagram: Power Drive Card (PDC) and Associated Circuitry (sheet 2 of 2)

PDCP

(Serial Numbers PDCP 60000 and above)
Refer to pages 11 - 15 and 11 - 16 for block diagrams of the PDCP.

NOTE: Although PDCP Cards may be used with a CPA chassis, all component references in this section refer to use with DRC Cards only. Refer to the "Reverse Relay Enable" description on Page 11 - 10 for use with the CPA chassis.

Brake Circuit Q1, Q2, Q3

The Brake Circuit is used to stop the plunger motor at the end of an injection, or if an error condition occurs during the injection. This process is called Dynamic Braking. When the Safe Relay opens, the motor will continue to turn, thereby acting as a generator producing voltage. When the brake is activated, the motor winding is connected across two .75 ohm, 5 watt resistors, stopping the motor. At the end of an injection, the error signal (ERRSIG, a command from the Servo Control Card) goes negative (-1V), activating the Brake Sensing Circuit Q1 - Q3, thus stopping the motor. Zener diode D1 protects Q1 by limiting gate to source voltage to 15 volts. A SYSTEM OVERRIDE, AUX MONITOR, or overrate condition can also activate the brake.

Overcurrent Shutdown U1A, DRC Q1

The Overcurrent Shutdown Circuit opens the plunger motor voltage path if excessive current is flowing through the motor circuit. Sampling Resistor R4 (on DRC) is in series with the motor, and voltage across it is directly proportional to the current through the motor. This voltage is an input to Motor Current Amplifier U1D, the output of which is applied to the non-inverting input of Overcurrent Shutdown comparator U1A. The inverting input to U1A is connected to a voltage divider, establishing an Overcurrent Shutdown reference. When output of U1D rises above reference voltage at U1A, the output of U1A switches to negative saturation. This negative voltage is applied to the gate of Overcurrent Shutdown FET Q1 on the DRC, forcing it into cut-off, and opening the motor voltage path.

Safe Relay / Safe Relay Enable K1, Q7

Safe Relay K1 completes the motor voltage path between the SCR Bridge stage, and the Plunger Motor. K1 also provides an additional pair of normally-closed contacts to allow the Mechanical Stop Motor to run while the injector is disarmed, yet prevent the Plunger motor from running. K1 is enabled by either a Forward or Reverse load command from the injector head, or when the injector is armed (Safe Relay Enable [SAFRELEN] from the SCC). In both cases, theses signals cause Q5 to conduct, providing a ground path to energize K1 (SAFRELO). This action disables the Mechanical Stop Motor by breaking connections to the motor, and allowing power to flow to the Plunger motor. The Safe Relay is disabled by a SYSTEM OVERRIDE/ AUX MONITOR from the PDCP, or a loss of the SAFRELEN from the SCC.

Single Button Disarm from Injector Head - When the injector is armed, and the SAFRELEN in the active high state, Q12 conducts, shunting R56. This process allows "Single Button" disarming of the injector head. When the injector is armed, if any single button on the injector head is pressed, the signal will go through either D15 or D16, then R59 and Q12, making Q13 conduct. This produces an active low FWD/REV IND (to the SCC Card), which prompts the system to withdraw the SAFRELEN.

Reverse Relay Enable Circuits K2, Q10, Q11

When Reverse loading, both Safe Relay K1 and Reverse Relay K2 must be energized. K2 reverses the polarity of the plunger. When REVERSE load is pressed, Q11 and Q10 conduct, applying +26 volts through on-board jumper JU1, energizing K2. JU1 must be set correctly to avoid: No Reverse, or; Latch in Reverse. See the tables below for proper settings:

Motherboard Configuration	*JU1 Setting*
RMB-2 Motherboards	2-3
CMB 4XXXX	1-2
MBR Motherboards	1-2

Power Chassis Configuration	*JU1 Setting*
Non-DRC Style 20000 series (CPA)	1-2
DRC Style 20000 series (CRP)	2-3
DRC Style 60000 series (CRP)	1-2

System Override

The SYSTEM OVERRIDE shuts down the PDCP if the system detects the presence of a "System Monitor' type condition (Overpressure, Overvolume, or Overrate [via Aux Monitor]). When the SYSTEM OVERRIDE signal from U16 (PIO3) on the SCC goes high, Q4 and Q5 (PDCP) conduct, allowing +15 volts to: Disable the Safe Relay circuit (Q6), activate the brake (D2 and Q1), and disable pulses to the SCR bridge controller (Q9). SYSTEM OVERRIDE and AUX MONITOR are OR'ed on the PDCP to form a redundant shut-down circuit.

Zero Crossing Detector U4A, U4D

The Zero Crossing Detector circuit establishes a timing reference for triggering of the SCR bridge. This is done by producing a positive pulse (-10v to +10v) which resets Ramp Generator U5C when the input sine-wave passes through zero. These pulses are also applied to Full Error Trigger Q9, through D6 and R30, to fire the SCR bridge when needed.

Input to this circuit is the added, positive half-waves, from Power Transformer T1, forming a full-wave input to U4A. U4A, an inverting amplifier with a gain of 1/10, together with D30 and C15, form a peak detector which produces an output voltage proportional to the incoming line voltage. This voltage sets the input reference for "Window Detector" U4D, which produces a positive output pulse when the input sine-wave is below the reference established by U4A (sine-wave passes through zero). All other times, the output of U4D is negative

saturation. The positive pulse, applied to the gate of Q16, resets the Ramp Generator. The pulse width is approximately 1.2 mS @ 60 Hz, and 1.5 mS @ 50 Hz, and is clamped to +/-10 volts by zener diodes D28 and D29 in the feedback loop of U4D.

Ramp Generator U5C, Q16

Integrator U5C generates 2 volt (-2 to 0 volt) ramp waveforms between each zero crossing that are used to establish a reference level for Trigger Comparator U5B. DC level and amplitude of the ramps are adjusted by R90 and R112, respectively. The integrator is reset when the sine-wave passes through zero (U4D applies a positive pulse to the gate of Q16).

Trigger Comparator, SCR Controller U5B, Q8

Trigger Comparator U5B uses the summed Error, or load profile, signal and ramp wave-form to determine at what point in the sine-wave the SCR bridge is fired. In standby, input to U5B is a negative voltage (-2 to 0 volt integration from U5C), thus output of U2D is negative saturation, and Q8 is off.

During injection, or when forward or reverse loading, the DC signal raises the ramp wave-form input to U5B above zero volts, causing output of U5B to enter positive saturation, making Q8 conduct. Q8 provides a ground path for +26 volts (through R27, R28, and Q8), which creates a positive to negative transition on the primary of pulse transformer T1. The pulse transformer is connected, to invert the polarity of the secondary, creating a negative to positive pulse to fire the SCR bridge. The duration of the pulse is determined by C4, R28, and the primary of T1.

Full Error Trigger Q9

The Full Error Trigger will fire the SCR bridge if a large, instantaneous Error signal does not allow U5B to trigger the SCR bridge. In order for Trigger Comparator U5B and the SCR Controller to fire the SCR bridge, input to U5B must be allowed to go below zero. If the Error signal is too large, input of U5B stays above zero, consequently, output is held in positive saturation. When this occurs, positive pulses from Zero Crossing Detector U4D will make Q9 conduct. This transition momentarily resets SCR Controller Q8, to enable the next positive output from U5B to fire the SCR bridge. Pulses will continue to reset the SCR controller until the Error signal drops to a value which allows U5B to take over.

Transistor Q9 is used to ground trigger pulses (remove base voltage to Q8) if a SYSTEM OVERRIDE (D8 and D9), AUX MONITOR (D10 and D9), or overrate injection (D11 and D9) occurs.

Delinearizing Network

The circuit comprised of R75, R87, R88, R107-110, D26, D27 and C10, increases drive circuitry sensitivity to small error signals, and decreases sensitivity to larger error signals.

Power Output Stage

AC power from the power transformer is applied to SCR bridge Z1. The output of the bridge, controlled by gate pulses from the SCR controller, is filtered by C3 (on DRC). The SCR bridge is protected by an internal MOV across the AC input. SCR Bridge output is spike protected by MOV Z2, while direction of motor rotation is controlled by Reverse Relay K2. Motor current is sampled for the pressure circuits and the Overcurrent Shutdown circuit by Sampling Resistor R4 on the DRC.

Pressure Signal Filter U1C

U1C is a non-inverting, low-pass filter that eliminates 50 and 60 Hz oscillations from the Motor Current signal.

Pressure Amplifier U1B

The filtered motor current signal is amplified by U1B. Output is the actual pressure signal PRESSIG, sent to the multiplexer and pressure limit circuitry on the SCC Card. This signal is also used on-card by the Loading Pressure limit. Pressure Amp U1B, a non-inverting amplifier, allows calibration of the Pressure signal. Low pressure is calibrated by R83, which adjusts the input offset to U1B, while high pressure adjustment is calibrated by R17, which adjusts the gain of U1B.

Loading Pressure Limit Control Circuit Q15, Q17, U5D

If the output of U1B indicates pressure in excess of 200 PSI, Q15 and Q17 conduct, summing a positive voltage with the negative load profile voltage (from U4C) to reduce the input to U5D. The lower input reduces the error signal to U5B, thus limiting load rate and pressure.

Motor Current Amplifier U1D

U1D amplifies and inverts the motor current signal from the sampling resistor, which is in series with the motor. Output of U1D is a negative voltage, proportional to motor current. This signal is used by Velocity Amplifier U2B, Auxiliary Monitor U2C, and Overcurrent Shutdown circuit U1A.

Velocity Amplifier U2B

Inputs to velocity amplifier U2B are motor voltage, and current signal from the motor current amplifier U1D; these two signals are opposite in polarity, and added to obtain an analog derivative of actual velocity. The output of U2B is negative, used by Overrate Detectors U2A and U2D. Output is also used to control the speed of the motor when loading (U5D).

Overrate Detector U2A

Overrate Detector U2A compares the actual velocity signal to the FLOW SELECTED input, and will shut down the PDCP if velocity exceeds the flow command. When this occurs, output of U2A nullifies input to Trigger Comparator U5B, stopping trigger pulses to the SCR bridge.

Brake Comparator U2D

The output of U2A is also sent to Brake Comparator U2D. If Overrate Detector U2A cannot adequately control the overate condition, U2D will activate the Brake (Q1), trigger an Aux Monitor (U2C), and short any remaining SCR bridge pulses to ground.

Auxiliary Monitor U2C

The AUX MONITOR circuit will shut down the PDCP if either of the following conditions exist: Excessive current flowing through the motor; Actual motor speed is greater than the selected flow rate. U2C, with diode D14 in the feedback loop, acts as a latch circuit. When either above stated conditions occurs, output of U2C goes positive, forward biasing D14, and feeding positive voltage to the non-inverting input (latching U2C positive). An AUX MONITOR will: Disable pulses to the SCR bridge through D8, D9, and D10; Disable the Safe Relay Enable (SAFRELEN) through Q6; Activate the brake through D8 and D2; Send a signal to U16 (PIO3) on the SCC to interrupt the CPU and terminate the injection.

Excessive Motor Current:
The inverting input of U2C receives the motor current signal from Motor Current Amplifier U1D. Normally, this input is used to decrease the sensitivity of U2C at the beginning of an injection, thus preventing false Aux Monitor indications caused by initial motor voltage and current requirements at the beginning of an injection. As motor current increases, the inverting input goes negative (eventually to the point at which U2C output becomes positive). When this occurs, U2C will latch, shutting down the PDCP, sending a signal to U16 (PIO 3) on the SCC (prompting the system to terminate the injection).

Excessive Motor Voltage:
The non-inverting input to U2C receives the output of Brake Comparator U2D. Input to U2D is Overrate Detector U2A which senses if motor speed is greater than the selected Flow Rate. If an overrate is detected by U2A, U2D will send +15 volts to the non-inverting input of U2C, making its output positive. When this occurs, U2C will latch, shutting down the PDCP, sending a signal to U16 (PIO 3) on the SCC (prompting the system to terminate the injection).

Forward/Reverse Loading Circuit U3, U4B, U4C, U5D

The Forward/Reverse Loading circuit develops a load profile voltage which is summed with the output of Ramp Generator U5C, to trigger the SCR bridge and produce a drive voltage for the plunger motor. Plunger pressure and velocity when loading are controlled by Error Amplifier U5D. This loading circuit is compatible with both Mark V and Mark V *Plus* Injector Heads, with a description for the operation of both below:

Mark V Injector Head:
Forward or Reverse loading sends +26 volts input to the loading circuit (junction of R67 and R82). The circuitry of R67, R82, D20, D21, and Q14, clamp the input voltage to U4C at +4.3 volts, simulating the load profile developed on the original Mark V PDC. U4C generates a negative load profile which is inverted by Error Amplifier U5D to produce an error signal. This error signal is summed with the Ramp Generator output to trigger the SCR bridge. Capacitor C16 provides the slow start to simulate the original PDC.

Mark V *Plus* Injector Head:
Forward or Reverse loading sends a voltage that ranges from +7.9-12.9 volts (slow to fast). This voltage is sent to U4C (clamping by D20 not required), generating a negative load profile (-1.5 to -6.5) which is inverted by Error Amplifier U5D to produce an error signal. This signal is summed with the Ramp Generator output to trigger the SCR bridge. Ten Volt Regulator U3 and Inverter U4B supply -10 volts to the input of U4C. The summation of -10 volts and the load rate command voltage at U4C, produce a 0 volt velocity command voltage in standby mode, or when only one button is depressed on the injector head.

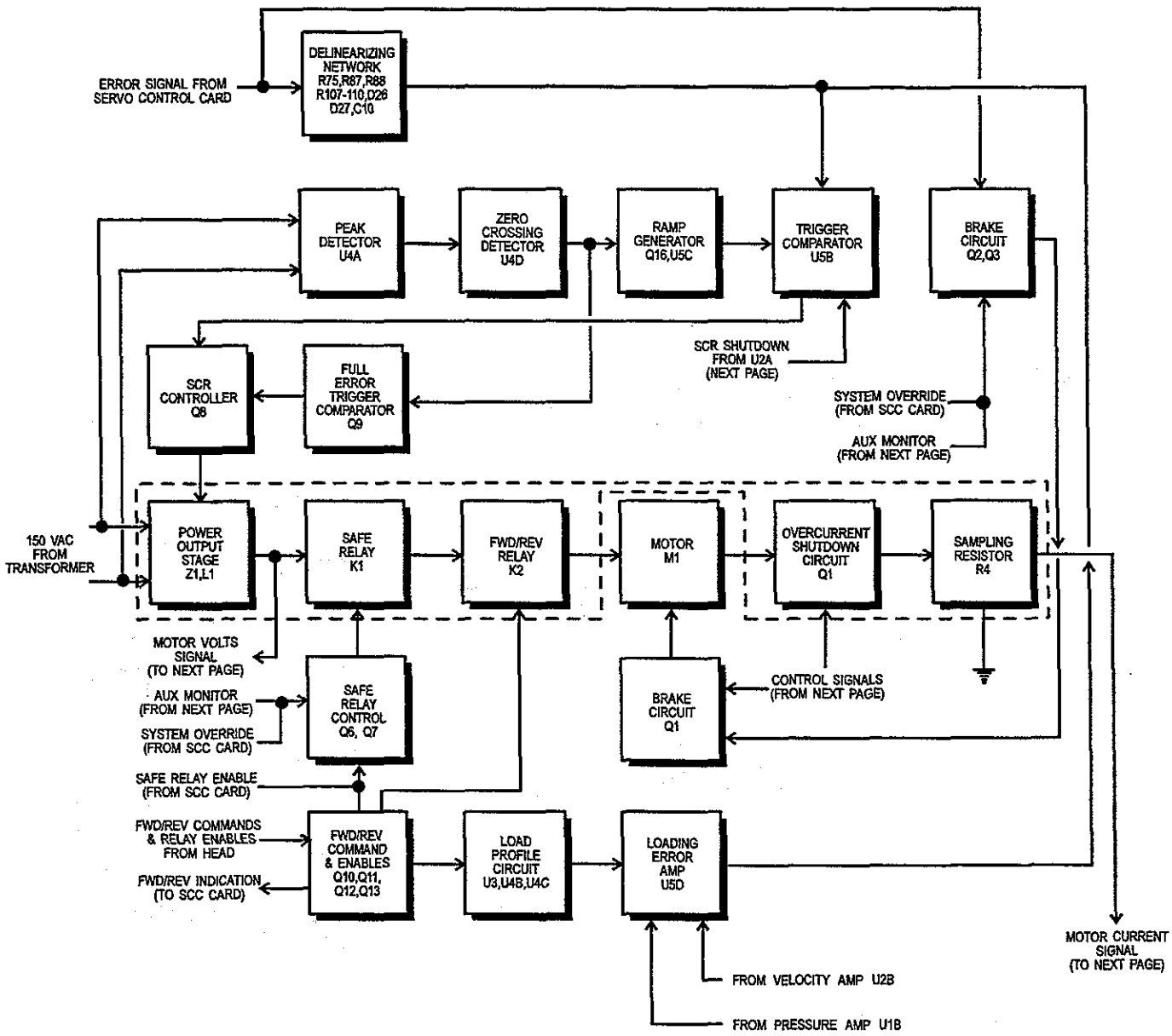
Fwd/Rev Loading Error Amplifier U5D

Error Amplifier U5D controls the plunger velocity and pressure limit when forward or reverse loading. Below are descriptions of velocity and pressure limit control.

Velocity Control:
U5D controls motor velocity by increasing or decreasing the error signal, based upon comparisons of the Load Profile (U4C), and inverted Velocity signal (U2B and U5A). U4C produces a load profile voltage that indicates the desired speed of the motor, while Velocity Amplifier U2C produces an output voltage that represents the actual speed of the motor. The Velocity signal is inverted by U5A, and summed with the Load Profile at the inverting input to U5D.

If there is a negative difference (actual plunger rate is below the desired plunger rate), U5D will increase the error signal, firing the SCR bridge earlier in the sine-wave, producing more power for the motor. Likewise, if there is a positive difference (actual plunger rate is above the desired plunger rate), U5D will decrease the error signal, firing the SCR bridge later in the sine-wave, producing less power for the motor.

Pressure Limit Control:
If the output of U1B indicates pressure in excess of 200 PSI, Q15 and Q17 conduct, summing a positive voltage with the negative load profile voltage (from U4C) to reduce the input to U5D. The lower input reduces the error signal from U5B, thus limiting load rate and pressure.



*NOTE: *Blocks that appear within the dotted lines are not located on the PDCP.*

Figure 11.3: Block Diagram: Power Drive Card Plus (PDCP) and Associated Circuitry (sheet 1 of 2)

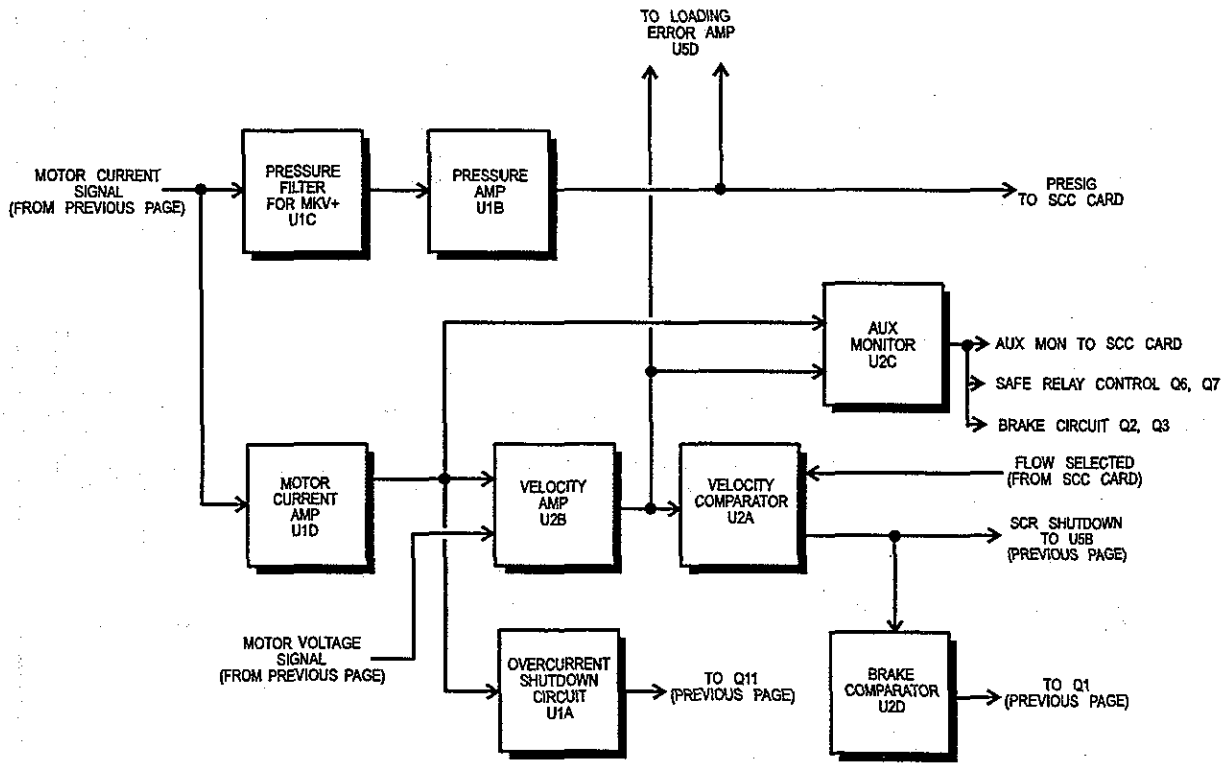


Figure 11.4: Block Diagram: Power Drive Card Plus (PDCP) and Associated Circuitry (sheet 2 of 2)

PDCI

(Serial Numbers PDCI 70000 and above)
Refer to pages 11 - 23 and 11 - 24 for block diagrams of the PDCP.

Brake Circuit Q1, Q2, Q3

The Brake Circuit is used to stop the plunger motor at the end of an injection, or if an error condition occurs during the injection. This process is called Dynamic Braking. When the Safe Relay opens, the motor will continue to turn, thereby acting as a generator producing voltage. When the brake is activated, the motor winding is connected across two .75 ohm, 5 watt resistors, stopping the motor. At the end of an injection, the error signal (ERRSIG, a command from the Servo Control Card) goes negative (-1V), activating the Brake Sensing Circuit Q1 - Q3, thus stopping the motor. Zener diode D1 protects Q1 by limiting gate to source voltage to 15 volts. A SYSTEM OVERRIDE, AUX MONITOR, or overrate condition can also activate the brake.

Overcurrent Shutdown U1A, DRC Q1

The Overcurrent Shutdown Circuit opens the plunger motor voltage path if excessive current is flowing through the motor circuit. Sampling Resistor R4 (on DRCI) is in series with the motor, and voltage across it is directly proportional to the current through the motor. This voltage is an input to Motor Current Amplifier U1D, the output of which is applied to the non-inverting input of Overcurrent Shutdown comparator U1A. The inverting input to U1A is connected to a voltage divider, establishing an Overcurrent Shutdown reference. When output of U1D rises above reference voltage at U1A, the output of U1A switches to negative saturation. This negative voltage is applied to the gate of Overcurrent Shutdown FET Q1 on the DRCI, forcing it into cutoff, and opening the motor voltage path.

Safe Relay / Safe Relay Enable K1, Q7

Safe Relay K1 completes the motor voltage path between the SCR Bridge stage, and the Plunger Motor. K1 also provides an additional pair of normally-closed contacts to allow the Mechanical Stop Motor to run while the injector is disarmed, yet prevent the Plunger motor from running. K1 is enabled by either a Forward or Reverse load command from the injector head, or when the injector is armed (Safe Relay Enable [SAFRELEN] from the SCC). In both cases, theses signals cause Q5 to conduct, providing a ground path to energize K1 (SAFRELO). This action disables the Mechanical Stop Motor by breaking connections to the motor, and allowing power to flow to the Plunger motor. The Safe Relay is disabled by a SYSTEM OVERRIDE/ AUX MONITOR from the PDCI, or a loss of the SAFRELEN from the SCC.

Single Button Disarm from Injector Head - When the injector is armed, and the SAFRELEN in the active high state, Q12 conducts, shunting R56. This process allows "Single Button" disarming of the injector

head. When the injector is armed, if any single button on the injector head is pressed, the signal will go through either D15 or D16, then R59 and Q12, making Q13 conduct. This produces an active low FWD/REV IND (to the SCC Card), which prompts the system to withdraw the SAFRELEN.

Reverse Relay Enable Circuits K2, Q10, Q11

When Reverse loading, both Safe Relay K1 and Reverse Relay K2 must be energized. K2 reverses the polarity of the plunger. When REVERSE load is pressed, Q11 and Q10 conduct, applying +26 volts through on-board jumper JU1, energizing K2. JU1 must be set in position "1-2".

System Override

The SYSTEM OVERRIDE shuts down the PDCI if the system detects the presence of a "System Monitor' type condition (Overpressure, Overvolume, or Overrate [via Aux Monitor]). When the SYSTEM OVERRIDE signal from U16 (PIO3) on the SCC goes high, Q4 and Q5 (PDCI) conduct, allowing +15 volts to: Disable the Safe Relay circuit (Q6), activate the brake (D2 and Q1), and disable pulses to the SCR bridge controller (Q9). SYSTEM OVERRIDE and AUX MONITOR are OR'ed on the PDCI to form a redundant shut-down circuit.

Zero Crossing Detector U4A, U4D

The Zero Crossing Detector circuit establishes a timing reference for triggering of the SCR bridge. This is done by producing a positive pulse (-10v to +10v) which resets Ramp Generator U5C when the input sine-wave passes through zero. These pulses are also applied to Full Error Trigger Q9, through D6 and R30, to fire the SCR bridge when needed.

Input to this circuit is the added, positive half-waves, from the 36 VAC created by a circuit on the Motherboard (MBRI), forming a full-wave input to U4A. U4A, an inverting amplifier with a gain of 2.06, together with D30 and C15, form a peak detector which produces an output voltage proportional to the incoming line voltage. This voltage sets the input reference for "Window Detector" U4D, which produces a positive output pulse when the input sine-wave is below the reference established by U4A (sine-wave passes through zero). All other times, the output of U4D is negative saturation. The positive pulse, applied to the gate of Q16, resets the Ramp Generator. The pulse width is approximately 1.2 mS @ 60 Hz, and 1.5 mS @ 50 Hz, and is clamped to +/- 10 volts by zener diodes D28 and D29 in the feedback loop of U4D.

Ramp Generator U5C, Q16

Integrator U5C generates 2 volt (-2 to 0 volt) ramp waveforms between each zero crossing that are used to establish a reference level for Trigger Comparator U5B. DC level and amplitude of the ramps are adjusted by R90 and R112, respectively. The integrator is reset when the sine-wave passes through zero (U4D applies a positive pulse to the gate of Q16).

Trigger Comparator, SCR Controller U5B, Q8

Trigger Comparator U5B uses the summed Error, or load profile, signal and ramp wave-form to determine at what point in the sine-wave the SCR bridge is fired. In standby, input to U5B is a negative voltage (-2 to 0 volt integration from U5C), thus output of U2D is negative saturation, and Q8 is off.

During injection, or when forward or reverse loading, the DC signal raises the ramp wave-form input to U5B above zero volts, causing output of U5B to enter positive saturation, making Q8 conduct. Q8 provides a ground path for +26 volts (through R27, R28, and Q8), which creates a positive to negative transition on the primary of pulse transformer T1. The pulse transformer is connected, to invert the polarity of the secondary, creating a negative to positive pulse to fire the SCR bridge. The duration of the pulse is determined by C4, R28, and the primary of T1.

Full Error Trigger Q9

The Full Error Trigger will fire the SCR bridge if a large, instantaneous Error signal does not allow U5B to trigger the SCR bridge. In order for Trigger Comparator U5B and the SCR Controller to fire the SCR bridge, input to U5B must be allowed to go below zero. If the Error signal is too large, input of U5B stays above zero, consequently, output is held in positive saturation. When this occurs, positive pulses from Zero Crossing Detector U4D will make Q9 conduct. This transition momentarily resets SCR Controller Q8, to enable the next positive output from U5B to fire the SCR bridge. Pulses will continue to reset the SCR controller until the Error signal drops to a value which allows U5B to take over.

Transistor Q9 is used to ground trigger pulses (remove base voltage to Q8) if a SYSTEM OVERRIDE (D8 and D9), AUX MONITOR (D10 and D9), or overrate injection (D11 and D9) occurs.

Delinearizing Network

The circuit comprised of R75, R87, R88, R107-110, D26, D27 and C10, increases drive circuitry sensitivity to small error signals, and decreases sensitivity to larger error signals.

Power Output Stage

AC power from the power transformer is applied to SCR bridge Z1. The output of the bridge, controlled by gate pulses from the SCR controller, is filtered by C3 (on DRCI). The SCR bridge is protected by an internal MOV across the AC input. SCR Bridge output is spike protected by MOV Z2, while direction of motor rotation is controlled by Reverse Relay K2. Motor current is sampled for the pressure circuits and the Overcurrent Shutdown circuit by Sampling Resistor R4 on the DRCI.

Pressure Signal Filter U1C

U1C is a non-inverting, low-pass filter that eliminates 50 and 60 Hz oscillations from the Motor Current signal.

Pressure Amplifier U1B

The filtered motor current signal is amplified by U1B. Output is the actual pressure signal PRESSIG, sent to the multiplexer and pressure limit circuitry on the SCC Card. This signal is also used on-card by the Loading Pressure limit. Pressure Amp U1B, a non-inverting amplifier, allows calibration of the Pressure signal. Low pressure is calibrated by R83, which adjusts the input offset to U1B, while high pressure adjustment is calibrated by R17, which adjusts the gain of U1B.

Loading Pressure Limit Control Circuit Q15, Q17, U5D

If the output of U1B indicates pressure in excess of 200 PSI, Q15 and Q17 conduct, summing a positive voltage with the negative load profile voltage (from U4C) to reduce the input to U5D. The lower input reduces the error signal to U5B, thus limiting load rate and pressure.

Motor Current Amplifier U1D

U1D amplifies and inverts the motor current signal from the sampling resistor, which is in series with the motor. Output of U1D is a negative voltage, proportional to motor current. This signal is used by Velocity Amplifier U2B, Auxiliary Monitor U2C, and Overcurrent Shutdown circuit U1A.

Velocity Amplifier U2B

Inputs to velocity amplifier U2B are motor voltage, and current signal from the motor current amplifier U1D; these two signals are opposite in polarity, and added to obtain an analog derivative of actual velocity. The output of U2B is negative, used by Overrate Detectors U2A and U2D. Output is also used to control the speed of the motor when loading (U5D).

Overrate Detector U2A

Overrate Detector U2A compares the actual velocity signal to the FLOW SELECTED input, and will shut down the PDCI if velocity exceeds the flow command. When this occurs, output of U2A nullifies input to Trigger Comparator U5B, stopping trigger pulses to the SCR bridge.

Brake Comparator U2D

The output of U2A is also sent to Brake Comparator U2D. If Overrate Detector U2A cannot adequately control the overate condition, U2D will activate the Brake (Q1), trigger an Aux Monitor (U2C), and short any remaining SCR bridge pulses to ground.